Engineering Library
APR 4 1918
UNIV. OF CALIFORNIA LIBRARY

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2.

VOL. CV.—No. 2723.] *LONDON: FRIDAY, MARCH 8, 1918.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...9d. BY INLAND POST ... 11½d.

Aveling & Porter, Ltd.,
ROCHESTER, KENT,
and 72, CANNON STREET, LONDON.
STEAM ROLLERS. ROAD LOCOMOTIVES.
STEAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 6030

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, page 33, last week.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

S.B. Iron and Steel Bars.
PLATES AND SHEETS.

Stringer Brothers,
WEST BROMWICH. 6025

Builders of Locomotives,
HEAVY and LIGHT.
All Gauges and Types.
Address: Export Department, H. K. PORTER CO., 11, Battery Place, New York.
Or R. S. COTTRELL, 3, London Wall Bldgs., London, England.
Cable Address—STAPERLY, NEW YORK.
New Catalogue 19 A mailed on application.

Harbour, Customs and Police Launches.
JOHN SAMUEL WHITE & COMPANY, LTD., Shipbuilders and Engineers, 6532
EAST COWES, I.W.

Petter Oil Engines.
Manufactured by 3801
PETTERS LIMITED, Engineers, Yeovil.
See our Illustrated Advt. every alternate week.

Craig & Donald, Ltd., Machine TOOL MAKERS, JOHNSTONE, near Glasgow.
For class of Machine Tools see our Illustrated Advertisement every alternate week. 1358

FOR
Sheet Metal Stampings or write PRESSINGS
GARTSHERRIE ENGINEERING & FORGE CO., 50, WELLINGTON STREET, GLASGOW. 6205

Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS. 5795
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH.

Brett's Patent Lifter Co. LIMITED.
Hammers, Presses, Furnaces, COVENTRY. 610

Bever, Dorling & Co., Ltd., BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

Cranes.—Electric, Steam, HYDRAULIC and HAND, of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 6451

The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 6530
Telegrams—"Cylinders," Birmingham.

Weldless-Steel Tubes for Water-Tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. 3179

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS, GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.

Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 6093
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Tank Locomotives
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 6450

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 107, March 1. 6485

Cranes.—Steam and Electric.
STEAM NAVVIES, GRAB CRANES, SHIPS DECK MACHINERY.

John H. Wilson & Co., Ltd.
DOCK ROAD, BIRKENHEAD. 6554
London Office:—15, Victoria Street, S.W.

The Norman Thompson Flight Co., Ltd. (RSTD. 1909.)
CONTRACTORS TO THE ADMIRALTY.
"THE FIRM WHO GAVE THE FLYING BOAT TO THE NAVY."
ALL BRITISH BUILT. 6165
Works:—MIDDLETON, BOGNOR, ENGLAND.
London Office:—DEWAR HOUSE, 11, HAYMARKET.
Telegrams—"Soaring, Bognor." Telephones—Bognor 43.
"Entidyte, Charles, London." Gerrard 7389

"Gripoly"
MACHINE BELTING
FOR
Driving
Conveying
Elevating
SOLE MANUFACTURERS
Lewis & Tylor, Ltd.,
CARDIFF. 6205
LONDON. MANCHESTER. GLASGOW.

Iron and Steel
Tubes and Fittings. 6145
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 93.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, Merrill's Patent TWIN STRAINERS for Pump Suctions. } Row's PATENTS.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-Class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

Tubes, Iron and Steel.
Edwin Lewis & Sons, Ltd., Wolverhampton. 6408

Tubes and Fittings, IRON AND STEEL.
Stewarts and Lloyds, Ltd.,
41, OSWALD ST., GLASGOW.
BROAD STREET CHAMBERS, BIRMINGHAM; and LONDON OFFICE—
WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—167, UPR. THAMES ST., E.C.
LIVERPOOL WAREHOUSE—83, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—122, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHEEPCOTE STREET, and 10, COLESHILL STREET.
See Advertisement page 28. 6462

CO^2 Plants (CARBON DI-OXIDE)
for Chemical & Mineral Water Mfrs. & Breweries.
READ & CAMPBELL, Ltd., 189, Victoria St., London, S.W. Telegrams—"Valerum, London."

CO^2 Fire Extincteurs
for Public and Private Bldgs., Electric Railways, &c.
THE BRITISH FIRE APPLIANCES CO., Ltd., 100, Victoria St., London, S.W. Telegrams—"Nenacid, London."

Crittall. Crittall.
CHEMICAL ANALYSIS.
Physical Tests.
Microscopical Examinations.
Heat Treatment & Pyrometer Tests.
Critical Range Determinations.
SCALE OF FEES ON APPLICATION.
THE CRITTALL MANUFACTURING CO., LTD., BRAINTREE, ESSEX.
Chief Metallurgist, H.S. PRIMROSE.
Crittall. Crittall. 6057

Separators
FOR
EXHAUST STEAM TURBINES COMPRESSED AIR, &c.
STEAM DRYERS.
METALLIC PACKINGS.
Princeps & Co., SHEFFIELD. 5191

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS, OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Od 3547
Registered Offices: 108A, CANNON ST., LONDON, E.C.

CHANTIERS & ATELIERS
Augustin - Normand
67, rue de Perray—LE HAVRE (France.) 3880
Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Excavators.
FROM 50 TO 600 YARDS PER HOUR.
D. Whitaker, 6263
1, UNION STREET, LEICESTER.

Yarrow Patent Water-Tube Boilers. 6094
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY CARRIAGES, ELECTRIC CARS, &c.
Hurst Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3389

Head, Wrightson & Co., LIMITED.
See Advertisement page 37, Feb. 15. 3402

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED.
Duckham's Patent Suspended WEIGHING MACHINES.—BAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 15. 6271

Gas Engines, Suction Plants, Inspections, Tests and Reports. Expert advice.—E. J. DAVIS, M.I.Mech.E., Great Eastern Road, Stratford. Telephones: East 1350; Stratford 869. Tel.: Rapidizing, London. 1794

Steel Castings.
THOMAS SUMMERSON & SONS, LTD., DARLINGTON. 6309

Patent Hydro-Pneumatic
See's Ash Ejector.
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 50 ft. clear of vessel.—Apply F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4335

Rubber MANUFACTURERS
Hose Steam and Air Drill
GUTTA PERCHA & RUBBER, LIMITED.
Toronto - - Canada. 5916

Aluminium. 6 SECTIONS. Normally employed for—MOULDINGS, REFLECTORS, BOW COLLECTORS, STEP BEADING, &c. 5919
THE BRITISH ALUMINIUM CO., LTD., 109, Queen Victoria St., London, E.C. 4.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 6246
See half-page Advertisement page 87, Feb. 22.

B. & S. Massey, Ltd., MANCHESTER.
Steam Hammers, Power Hammers, Drop Stamps, Band Saws. 6479
QUICK DELIVERY. LARGE STOCK.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMMYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 6661

London Association of FOREMEN ENGINEERS.

Established 1852.
Foremen, Managers and Employers connected with the Engineering Industry.
MONTHLY MEETINGS are held at the Cannon Street Hotel, E.C.
Membership is not confined to residents in London
Secretary:
JAMES HARRINGTON, K 6
85, Salisbury Road, Harrow, Middlesex.

IN THE HIGH COURT OF JUSTICE — CHANCERY DIVISION — Mr. JUSTICE YOUNGER, 1918 A. 02.

IN THE MATTER of ALGERIAN OILFIELDS Limited and Reduced and IN THE MATTER of THE COMPANIES (CONSOLIDATION) ACT 1908.

Notice is Hereby Given

that the Order of the High Court of Justice Chancery Division dated the 19th day of February 1918 confirming the reduction of the capital of the above named Company from £500,000 divided into 500,000 shares of £1 each (of which 304,904 shares have been issued and are outstanding and fully paid, 63,688 shares have been forfeited for non-payment of calls and 131,408 shares have never been issued) to £225,586 8s. divided into 304,904 shares of 3s. each and 195,096 shares of £1 each and that such reduction be effected by cancelling capital which has been lost or is unrepresented by available assets to the extent of 18s. a share upon each of the 304,904 shares which have been issued and are outstanding. That on such reduction taking effect each of the 63,688 shares of the Company which have been forfeited and the 131,408 shares which have not been issued be subdivided into 10 shares of 2s. each, and the Minute approved by the Court showing with respect to the share capital of the Company as altered the several particulars required by the above Act were registered by the Registrar of Companies on the 27th day of February 1918.

The said Minute is in the words and figures following:—

"The Capital of Algerian Oilfields Limited and Reduced is henceforth £225,586 8s. divided into 2,255,864 shares of 2s. each reduced from the original capital of £500,000 divided into 500,000 shares of £1 each. At the time of the registration of this Minute (a) the sum of 2s. per share has been and is to be deemed to be paid up on the 304,904 shares which have been issued and have not been forfeited and (b) nothing 4s to be deemed to have been paid up on the 1,950,960 shares which have never been issued or have been forfeited."

Dated the 28th day of February 1918.
MACKRELL, MATON, GODLEE & QUINCEY,
21, Cannon Street, E.C. 4. K 609
Solicitors for the said Company.

Correspondence Courses for

B.Sc., A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E.
Tuition in separate subjects, if desired.
Thorough, rapid, efficient coaching under my personal supervision.
S. T. G. ANDREWS, B.Sc. (Eng.), Dept. E. 2,
80, Shakespeare Crescent, Manor Park, E. 12.
K 303

Inst. C.E., I. Mech.E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 4600

A.M.I.C.E. and A.M.I.M.E.

Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—PENNINGTONS, 264, Oxford Road, Manchester.

APPOINTMENTS OPEN.

ESSEX COUNTY COUNCIL.

LEYTON HIGHER EDUCATION COMMITTEE.

ENGINEERING AND TRADE SCHOOL.

The Governors of the above-named School invite

Applications for the Post of HEADMASTER.

Experience in a Trade School or a Junior Technical Institute is desirable.
Candidates must hold the Degree of a British University in Engineering or Science or its equivalent. Evening Classes conducted in the same building will be under the Headmaster's control, and he will supervise Evening Classes of the Junior Commercial Institutes.
Salary £330, rising by annual increments of £20 to £450 per annum.
Forms of application, which should be returned not later than 23rd March, may be obtained from Mr. J. H. NICHOLAS, County Offices, Chelmsford. K 608

The Grammont Establishments WANT Engineering CHEMISTS or METALLURGISTS,

well up in the treatment of copper ores of all kinds. Good positions, with financial interests in results.—Address, CUIVRE ELECTRO A. GRAMMONT, 10 Rue d'Uzès à Paris. K 385

Analytical Chemist Required,

to take charge of the Chemical Section of Laboratory, controlling machine shops, iron foundries and bronze foundry. Candidates must have had first-class experience in the analysis of high speed, alloy and straight steels, and be thoroughly conversant with the chemical laboratory work in connection with iron and bronze foundries, including the controlling of cupolas. Applicants should give full particulars of their training and particularly their foundry experience; also state age and salary required. The position is permanent and holds good prospects for a suitable man.—Apply, ALFRED HERBERT, LTD., Machine Tool Makers, Edgwick Works, Coventry. K 606

CORPORATION OF CALCUTTA.

WATER WORKS SUPERINTENDENT.

Applications are Invited for

the post of SUPERINTENDENT in the Water Works Department of the Corporation of Calcutta, on a salary of Rs. 400/-, rising by annual increments of Rs. 20/- to Rs. 500/- per month, with a fixed conveyance allowance of Rs. 50/- per month.
Applicants must possess a good all-round experience of some large Water Works and should be well up in waste prevention and pipe-laying. They should also have a good knowledge of plumbing and some knowledge of building work.
In the case of a candidate selected in the United Kingdom, second-class passage from London to Calcutta, with half pay on the voyage will also be paid, but he will have to submit to a medical examination in London.
The person appointed will be subject to the leave and other rules in force in the Corporation, and will be required to subscribe to the Provident Fund.
Applications, stating age and qualifications, and giving full particulars of experience, together with copies of testimonials and accompanied by a medical certificate of recent date, showing that the candidates are of sound constitution and in good health, and addressed to the Secretary, Municipal Office, Calcutta, will be received up to the 1st May, 1918, or up to the date of the receipt in Calcutta of letters posted in the United Kingdom on or before the 15th March, 1918.
C. C. CHATTERJEE, Secretary,
Corporation of Calcutta.
5, Corporation Street, Calcutta,
11th January, 1918. K 619

Wanted, Metallurgical

CHEMIST, to take complete charge of new works manufacturing Anti-friction Bearing Metals. Must have had good practical knowledge in the manufacture of high-grade tin basis metals. State qualifications, experience and salary required.—Address, K 616, Offices of ENGINEERING.

General Manager, of Proved

commercial and technical administrative ability, WANTED for important Mechanical Engineering Works.—Address, K 455, Offices of ENGINEERING.

Vacant Position for Man of

high administrative qualities, in the management of important Electrical Manufacturing concern.—Address, K 456, Offices of ENGINEERING.

Assistant Works Manager

WANTED, for large Engineering Works, comprising machine and anvil smith shop, grey and malleable iron foundry, machine shop and galvanising department. No person already on Government work will be engaged.—Apply, giving full particulars as to previous experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4799. K 602

Inspector, for Jig and Tool

Aeronautical work, for Government Controlled Establishment, situated in Eastern Counties.—Apply, stating age, experience and salary required, to nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 590. No one already on Government work can be engaged.

Wanted, Immediately, Rate

FIXER, for large Aeroplane Works in the Midlands. One with experience in Wood Work and Erection would be preferred. No one already on Government work will be employed.—Apply, to your nearest EMPLOYMENT EXCHANGE, quoting this Journal and K 593.

Assistant to Works Engineer

REQUIRED, accustomed to the control of men and the maintenance and repair of all types of steelworks plant.—Apply, giving full particulars of training, experience, age and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and quoting No. A 4756. No one on Government work can be engaged. K 514

An Important Swiss Engi-

neering Works, specialised in Silico Calcareous and Agglomerate Brick and Cement Manufacturing Plants, in Paste Goods Factories, and in Machinery for Bread Making and Baking, REQUIRES an experienced ENGINEER for Great Britain. One who has had previous connections with Switzerland preferred.—Send application to BUHLER BROS., Uzwil (Switzerland). K 521

Civil Engineer Required, with

Commercial Experience, for employment under a Government Department. Must be fully conversant with abstracting and ordering materials for civil engineering and constructional work. Must be ineligible for general military service. Good salary to the right man.
Apply in writing, stating age, experience, salary required and when at liberty, and enclose a copy of not more than three recent testimonials.
Replies to be addressed to the
CIVIL ENGINEER-IN-CHIEF,
Admiralty, S.W. 1.,
and to be marked "O. P. 1" in top left-hand corner of the envelope. K 534

Section Engineers

REQUIRED, to carry out construction of sections of railway under the jurisdiction of the Federated Malay States Railway Construction Department, and to keep all the accounts, records, &c., in connection with the work. Must be fully qualified railway engineers, capable of setting out and constructing all work in construction with a railway. Engagement on agreement for two years. Salary £400 per annum with a duty allowance of £40 per annum and commuted field allowance of £50 per month. Free unfurnished camp quarters. Free passages. Candidates, who must be unmarried, between 28 and 45 years of age, and ineligible for military service, should apply at once by letter, stating age and why ineligible for military service, and giving full particulars of training and experience to Messrs. GREGORY BYLES & WARING, 12, Dean's Yard, Westminster, S.W. 1, quoting M/8311. K 676

Wanted, Engineers, Expe-

rienced in estimating cost of machining work and fixing piecework prices or bonus times on Aeroplane work. Applicants must have long workshop experience and certain amount of technical knowledge. No person resident more than ten miles away or already engaged on Government work will be engaged.—Apply, D. T. C., Room 123, Charing Cross Buildings, London, W.C. K 607

Wanted, Temporarily, for

firm dealing with production of non-inflammable Celluloid and imitation Horn, an ENGINEER with experience of special machinery for this class of work and able to deal with colour effects in material. Must have experience of Electrical Steam and Water Power. Good salary to fully qualified man.—Address, stating full particulars of experience, EXCLUSIVE BOX 382, care of MITCHELL'S Advertising Agency, 1, Snow Hill, E.C. 1. K 526

Foreman Engineer, Water-

works Pumping Station in Midlands, country district. Wages £16 per month, with cottage, coal and oil, and small travelling allowance. Apply, with full particulars and copies of two recent testimonials.—Address, K 595, Offices of ENGINEERING.

Representative Wanted by

large firm of Manufacturers and Merchants holding important Engineering Agencies in the North of England. Must be of good address and undoubted integrity, and possess engineering knowledge. District to be covered: Northumberland, Durham, and Cleveland. No person already on Government work will be engaged.—Apply in the first instance, stating age, experience and salary required, to K 625, Offices of ENGINEERING.

Buyer, Experienced on

Materials and Accessories for Motor Lorries and Cars. Permanent position for suitable man. Large firm in Midlands.—Apply, giving full particulars of previous experience and salary required, to K 515, Offices of ENGINEERING

Assistant General Manager

REQUIRED for Manufacturing Engineering Business in the West of England. Must have had first-rate Works training with knowledge of modern methods of manufacture, experience in handling labour and also of the commercial side of an Engineering Business. Commencing salary about £400. Applicants should give full particulars of experience and state age and present position, in confidence.—Address, K 618, Offices of ENGINEERING.

Wanted, for Government

work in London, two Mechanical DRAUGHTSMEN, accustomed to the lay-out of factories and the design of special machinery. State medical category, salary required, and when at liberty.—BOX 1069, WILLING'S, 125, Strand, London, W.C. 2. K 666

Engineering Instructors

WANTED, men qualified in Civil, Structural and Electrical Engineering for service in London. The work would involve no standing, so would be suitable for discharged wounded service men; other applicants must be exempt from Military Service or over military age.—Address, stating age, qualification and salary expected to K 674, Offices of ENGINEERING.

Inspector Wanted for Sheffield

works for examining and gauging work. No man employed on Government work need apply.—Apply, giving account of experience and copy of testimonials to your nearest EMPLOYMENT EXCHANGE, quoting this Journal and K 665.

Wanted, Electrical Engineer,

for large Iron and Steel Works on North-East Coast. Practical and technical experience essential in H.T., three-phase and D.C. machines. Knowledge of general engineering an advantage. —State age, experience and salary expected to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4803. No person already engaged on Government work will be employed. K 600

Engineer (Skilled) Required

to take Charge of shift of men in Engine Room of large Hotel. Able to help with repairs and maintenance. State wages required.—Apply, SECRETARY, Queen Anne's Mansions, S.W.1. K 629

Assistant Metallurgist

REQUIRED in large Engineering Works. No person already on Government work will be engaged.—Apply, stating age, full particulars of training and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4790. K 567

Sales Department of Large

Firm of Machine Tool Manufacturers have VACANCY for MAN capable of Taking Charge of Correspondence, &c.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4837. No person already on Government work will be engaged. K 639

Engineer Required to Assist

on Staff at London Office, practical and theoretical knowledge of petrol and paraffin electric generating sets essential. Nobody already on Government work or residing more than ten miles away need apply.—Address, K 637, Offices of ENGINEERING.

There is a Vacancy in the

Offices of a firm of Chartered Patent Agents for a Senior TECHNICAL ASSISTANT, and also for a Junior. Applications from well-trained scientific men with no previous knowledge of patent practice would be considered. Replies would be treated as strictly confidential, and should contain full information as to training, qualifications, experience if any, age and salary expected.—Address, "ALPHA," BOX 193, SELLS, Ltd., 168, Fleet Street, E.C. 4. K 661

Wanted, Competent Works

MANAGER for Engineering Works engaged on production of small articles, such as screws, small bolts, &c., by automatic machinery. Must be used to dies, tools and jigs. The position is a permanency for progressive man. No one engaged on Government work need apply.—Write, stating experience, age, and salary required to K 643, Offices of ENGINEERING.

Aeroplane Designer Required

for Government Establishment situated in Eastern Counties. An excellent opportunity offered to man with first-class knowledge of detail design. Must be thoroughly competent, quick, and accurate Draughtsman.—Apply, stating age, experience, and salary required, to nearest EMPLOYMENT EXCHANGE, mentioning this paper and K 658. No one already on Government work can be engaged.

Draughtsman Wanted by a

large Controlled Engineering Works within 100 miles of London; age about 30, with good mechanical engineering training; up-to-date experience Portable and Traction Steam Engines and Boilers essential. No person already employed on Government work will be engaged.—Address, stating fully age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4435 and this Journal. K 526

Draughtsman, Mechanical

Engineering, with experience in Machine Design and modern methods, WANTED, for Controlled Factory; ineligible. No person already employed upon Government work will be engaged.—Applicants must apply to their nearest EMPLOYMENT EXCHANGE, mentioning ENGINEERING and K 589. Apply, with copies of recent testimonials, stating age, experience and salary expected.

Draughtsman Wanted, by

Firm in Midlands, accustomed to Structural and Rivetted Work. A knowledge of Water Softening Plants and Feed Water Heaters an advantage but not essential. Ineligible for army. No one already on Government work will be employed.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting this Journal and K 594.

Wanted, Experienced Jig

and Tool DRAUGHTSMAN, for large Aircraft Works in the Midlands. Experience on Aeroplane work an advantage but not essential. No one already on Government work will be employed.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting this Journal and K 592.

Draughtsman Wanted, by

Controlled Company in the Midlands, for Plant, Lay-outs and Design. A knowledge of jigs and tools desirable but not essential. No person on Government work will be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting this Journal and K 550.

Structural, Engineering and

Building DRAUGHTSMAN WANTED. No one already on Government work will be employed. —Apply, stating salary and experience, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 598.

Structural Draughtsman.—A

leading Controlled Firm have a VACANCY for an Estimating DRAUGHTSMAN with extensive knowledge of Structures to carry Electric Cranes and Runways and other live loads. Good prospects and permanency. No person already on Government work will be engaged.—Apply, stating fully, age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4658. K 158

Draughtsman, Experienced,

for Controlled Works, Electric Motors and Dynamos, Manchester district. State terms, experience. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4776. K 587

Wanted, Experienced

DRAUGHTSMAN for elevator and conveyor work on important Government contracts. No person resident more than 10 miles away or already on Government work will be engaged. Reply, stating age, experience, salary required, and when at liberty to BOX 816, T. B. BROWNE'S Advertising Offices, 163, Queen Victoria Street, E.C. 4. K 674

First-class Welder Wanted, to

train and take charge of about twelve female welders, in Government Controlled Establishment, situated in Eastern Counties.—Apply, stating age, experience and wages required, to nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 591. No one already on Government work can be engaged.

Several First-class Jig & Tool

DESIGNERS WANTED for small accurate Repetition Work, similar to Maxim gun parts; also Juniors required for detailing, in London District.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4630. No one on Government work will be employed. K 633

Draughtsman Wanted, with

experience in general Mechanical and Electrical Engineering. Government work. State particulars of experience, age and salary. Permanency for the right man.—Address, K 606, Offices of ENGINEERING.

Several Assistant Designers

and Mechanical DRAUGHTSMEN, with experience in deck machinery and ship engineering and fittings REQUIRED, for Admiralty work. Commencing salary according to experience.—Apply, stating age, experience, and present salary, to BOX 1059, WILLING'S, 125, Strand, W.C. K 610

Wanted, Draughtsman with

good mechanical training, able to get out detail drawings of extensions to existing Electric Generating Station Plant, including pipework, but not cables. State full particulars, including age, qualifications and salary expected. No person already engaged on Government work will be employed. — Reply to nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 654.

Wanted Immediately, for

War Office Department in London, first-class DRAUGHTSMEN, accustomed to Crane, Elevator or General Engineering work. No one already employed on Government work will be engaged. State age, salary and experience to your nearest EMPLOYMENT EXCHANGE, quoting K 638, and this Journal.

Draughtsman Wanted, with

experience in motor vehicle design. Commercial vehicle experience desired but not essential. Good salary and prospects for man with initiative and the right experience.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4748. No person already employed on Government work will be engaged. K 647

Appointments Open continued on page 135.

LITERATURE.

Street Railway Fares, their Relation to Length of Haul and Cost of Service. By DUGALD G. JACKSON, Professor of Electrical Engineering, and DAVID J. MCGRATH, Research Assistant at the Massachusetts Institute of Technology. New York: McGraw-Hill Book Company; London: Hill Publishing Company. [Price 10s. 6d. net.]

No disparagement of this work is intended by suggesting that it will probably be valued, in this country, at least, rather on account for the insight it affords into the fiscal system with regard to American street cars and suburban traffic, than for its analysis and dissection of the causes that operate in determining the amount of fare or the method of its collection. Few subjects have been examined with greater care or more minuteness than the distribution of tram traffic and the causes that promote its fluctuations. The individual fare is so small, and its subdivision among the items of expenditure so many and various, that the closest watchfulness is necessary to avoid extravagance and to ensure efficiency. On all the main points discussed here our tram management has little to learn. The comparison between the American and English systems is, however, distinctly interesting and desirable, and the value of this comparison would have been greater, if the scope of the work had permitted the authors to trace the origin of the adoption in the two countries of systems so utterly opposed as these. The English plan of paying by distance travelled, that is, practically by mileage, possesses the inconvenience of many small and variable increments, but has much to recommend it independent of the acquired habit, which may be easily overrated. On the other hand, the adoption of a flat rate available over a considerable area, capable of extension where the privilege of free transfers obtains, apparently contains the vicious principle of putting a high mileage rate upon the short-distance passenger for the benefit of those making a longer journey. The inflexibility of a unit fare possesses inconveniences to which reference will be made later.

The origin of the book strikes us as not a little curious. The conclusions arrived at are not the deductions of experience, disciplined by tradition, but express the judgment of scientifically trained amateurs. The inferences are the result of an academical exercise, undertaken by the research division of the Electrical Engineering Department of the Massachusetts Institute of Technology, expressly endowed with funds to conduct a research into the economics of the street railway industry, with particular reference to the alleged inadequacy of the 5-cent fare to provide good public service, with provision for the necessary renewals and betterment, and at the same time to allow the owners of the railway a just return upon their investment. This form of inquiry ensures a certain freshness of treatment, but to those familiar with similar investigations and with the abundant statistics that have been collected, some of the conclusions, which are stated with great elaboration, have the appearance of axioms, and others will need qualification or restriction to the particular area and circumstances in which the investigation has been made.

For instance, no one will doubt but that the average cost of service per passenger will depend mainly upon the "density of traffic;" that is, the number of paying passengers per car-mile. Similarly it goes without saying that a general increase in flat-rate fares tends to reduce traffic, and that there must be a rate at which the gain from the higher unit fare is counterbalanced by the loss of numbers. The consideration here raised is merely a particular case of the more general problem which arises when fixing the price at which an article protected by a monopoly should be offered to the public so as to secure the greatest remuneration. Nevertheless the point is discussed with an earnestness that would lead one to think that it involved some novelty that had never come under the notice of railway experts. The conclusions reached, however, on such fundamental points are informing, since they demonstrate the conditions that obtain on American cars and illustrate the method of investigation that recommends itself to the scientific amateur. It can be authoritatively asserted from data derived from the traffic on thirty-five railways that the average number of passengers carried per car-mile is approximately 6.5, and occasionally, where traffic is densest, reaches the maximum of 7. At the same time it is shown that under the most favourable conditions of minimum taxes, operating expenses, and small initial capital investment, at least five passengers must be carried per car-mile in order that the company may pay a dividend of 7 per cent. On the other hand, when carrying seven passengers per car-mile a company should be reasonably certain of paying such a dividend. Incidentally it appears that the original capital subscribed varies from 16 cents to 23 cents per passenger carried per annum. Stated differently, out of every 5-cent fare, approximately 1.2 cents must be retained for return on investment if the undertaking is to be regarded as financially successful or giving a fair and just return. Such dividends may seem high, but it is maintained that some such return on capital is necessary, or was in pre-war days, in order to attract additional capital necessary for progressive development, extension and improvement of the existing undertaking. Fortified by important legal judgments as to the meaning of a "fair and just return," in the recommendations subsequently submitted by the authors provision has been made for such remuneration. Consequently it may be inferred that the street railway in the States is not a municipal or State undertaking, but the result of private enterprise, enjoying monopoly, in which the interests of the shareholders and the public may come in conflict. From time to time the relations between the two parties to the contract call for adjustment, and applications to the authorities for alterations in the fares and the establishment of easier conditions have apparently led to the preparation of these statistics, and submitted proposals. The necessity of some drastic reform is demonstrated by two facts—the steady increase in the amount invested per passenger carried and the gradual decrease in the average rate of return. For the year ended June 30, 1915, the Massachusetts Public Service Commission showed that out of 53 companies, 20 declared and paid no dividend for that year, and of the 33 which made some payment, only 14 paid 6 per cent. or over on their common stock.

The second point selected for illustration, that the effect of increase of fare tends to reduce the number of passengers, is so self-evident that it would not need comment, did it not lead naturally to the discussion of suggestions that have been made with the view of improving the fiscal position of the companies. When faced with a deficit, the readiest plan, though not a scientific, is to increase the fare, and acting under this inspiration, in some instances flat rates have been raised to 6 cents and even 7 cents. The principle of "what the traffic can bear" has been disregarded; in every case the result has been a diminution of traffic and the financial aspect has not been made more encouraging. Such a crude plan is unsound, because it tends to benefit the proportionately small number of long riders at the expense of the short, so that by the maintenance of the flat-rate system the "long-haul" passenger is paying less in proportion to the cost of his ride than the "short-haul" passenger. The vicious system of enforcing a uniform flat rate over a very considerable length of line is responsible for much mischief, and the evil increases with the natural extension of route due to the increase of population. But so ingrained is the habit of paying an inflexible unit fare that the American cannot break away from it. Any deviation from the rule raises a practically insurmountable opposition on the part of the public, and the whole body of street railway financiers and operators are equally adverse to proposals that would lower the fare rate.

That growing extension will compel the adoption of an improved system of fare collection seems inevitable. In Chicago, for example, the street railway extends 16 miles south of the business district, and a passenger can ride to the boundary for the modest "nickel." Nor is this all, the line extends 10 miles to the north of the city, and by obtaining a free transfer the passenger who has already travelled 16 miles can prolong his journey 10 miles further without any additional charge. The injustice of taxing many short riders to pay for a few long ones does not appeal to the American conscience. Nevertheless a scheme that lowered the fare unit for short riders and increased that of the long would prove beneficial to both the public and the railway, for it would increase the number of short journeys, which is the profitable part of the traffic, and discourage the long ones that entail a loss. The authors adumbrate such a scheme.

To strengthen their recommendations the authors discuss two instances in which the maintenance of the inelastic unit fare has had to yield to necessity. At Cleveland the long-continued conflict between the State authorities and the railway interests was dramatic in its character, and in many ways instructive; but we can only give the result, which has secured to that city the advantage of a fairly good service at an average rate of under 3½ cents per fare. At the same time 6 per cent. interest is practically guaranteed on the stock, but this latter result has not been accomplished without a drastic reduction of the original share capital. Some novel features in the way of sliding-scale charges have been introduced which complicate the scheme, but the financial position appears sound, and the escape from the rigour of a long-standing custom is a matter for congratulation. At Milwaukee, where the tram-lines extend from 10 miles south, to 8 miles north of the city, a compromise has been effected which is not without some good points. Over an area of, roughly, three miles from the centre, the 5-cent. fare is retained, but outside this area a number of zones are drawn, each about a mile in extent, and for passage through each of these zones an additional charge is made. The general effect has been to increase the number of fares in some directions and to diminish them in others, but the experiment conveys a useful object lesson, for where reduced fares have ruled the traffic has been larger, and where increased, smaller, but the gross revenue has diminished in each case. The greater number of passengers has not compensated for the lower fare, and in the other case the increased charge has not counterbalanced the loss from the reduced number of passengers. The experiment is instructive as far as it goes, and the authors are justified in deducing from it, in connection with other facts at which we have hinted, that sooner or later the street railways in the United States, both urban and suburban, will be forced to adopt a system of rates based more nearly on the distance travelled. The flat-rate system stands condemned as inadequate in many cases to meet the total cost of good service, and too inflexible to meet changing conditions in the costs of labour and material, and, moreover, it is discriminatory between long and short riders. "Some system based on distance or zone rates appears to be the only reasonable, just and generally satisfactory way to take proper care of present conditions and to prepare for the future."

Though the inquiry is limited to the management of American street railways and European conditions are excluded from the purview, the authors draw a comparison between the car service of America and that of this country. We gather that there is a conflict of opinion between the supporters of private ownership and those who look with favour on municipally controlled undertakings. The latter maintain that the big profits made by the American companies are contributed by the public, and that since the British officials can provide a satisfactory service at a lower rate, our management is more economical and efficient than in the States. The railway owners put up a good fight, and we should much like to take part in it. Of course they deny the good profits, and, as we have shown in many cases, justly, though 7 per cent. would satisfy most English railway investors. The advocates of private ownership stoutly assert, too, that more and better service is given than in England, that longer rides are possible, more contributed to taxation, and higher wages are paid to the staff. The authors, while reserving judgment, admit that our fares are lower. The "nickel" fare is as common in America as our average penny fare. But owing to less congestion and overcrowding in the States, the American passenger's length of ride exceeds ours

in the ratio of 3:2. Consequently, per mile, he pays approximately 2 cents, where we pay one halfpenny. Wages are higher in America than here; out of every 5-cent fare one cent is appropriated to paying the conductor and driver, while here the same service is rendered for about 0.43 cent. Writing before the war, the authors point out that capital could be obtained in Great Britain at about 3½ per cent. interest, whereas double that amount was required in the States to attract investors. Considering the favourable conditions prevailing in England, the authors intimate that we have scarcely made the most of our advantages, and claim that if the short-haul traffic of the British tramways ruled in the States, and the wages of labour employed in construction and operation could be reduced to half the present scale, "they could, with their existing management, easily equal the rates of fare which at present exist on the British tramways."

Terms of Industrial Peace. By ALEX. RAMSAY. London: Constable and Co., Limited. [Price 3s. net.]

THIS book, on a subject regarding which too much has been written, differs from most other works; first, because there is a definite attempt to show how the problem of industrial warfare can be met, and, second, because the proposals are based both upon an inside knowledge of the employers' needs and an experience of many years of contact with trade union labour and a sympathetic understanding of its attitude and ambition. The author states that he has lived as a workman; but he is now, obviously, an engineer holding a position which gives him "a knowledge of the complexity of our commercial and industrial organism." Moreover, he displays in his treatment of the subject a well-balanced judgment, and his review of the industrial situation discloses a full knowledge of the prevailing conditions and difficulties. The growing power of labour, he contends, is such that employers must approach the difficulties with a conciliatory constructive programme, and in this he recognises the need for effort on their part, as well as on the part of the workers, for increased production and lower selling price. This, of course, is to be achieved by specialisation, standardisation and manufacture in bulk.

The book has evidently been written before the issue of the Whitley Report, certainly before the War Cabinet decided to accept the main principles of this Report, and to organise works councils, district councils and national councils. This, however, corresponds generally with the basic idea of Mr. Ramsay's terms of industrial peace, but he carries his proposals one step further, and contends for arbitration in disputes before stoppage of work, with penalties for refusal to accept the terms of the arbitrator. He states that "to deal with the individual man in an industrial crisis is impracticable. But to deal with his trade union is possible. Unions have funds. The money required to maintain men on strike is not kept in the office of the general secretary, but is invested in stock, easily within reach of the Government. If they decreed that every day each man remained away from work a penalty should be extracted from this money invested, they would exercise an effective weapon which can really be applied. They could by this means assist trade union leaders to maintain discipline among the rank and file, and to curb those violent ebullitions of temper and manifestations of restlessness, which periodically break out into stoppages wholly unjustifiable and unnecessary." He admits that such a measure could only be made law by general consent, but considers that an absolutely just scheme for arbitration would be generally accepted. "Let it no longer be said that we have the genius to rule diverse races in far-flung empires, but cannot keep the peace at home; that we can reconcile peoples once hostile and bitter, but cannot find a means of bringing together our own, whose blood is one and best interests the same. If a man have a difference with his neighbour, the law does not permit him to settle it by physical violence. If a man is a creditor of his neighbour, he cannot take forcible possession of his neighbour's goods until he has the law's authority; such methods belong to savage days; social unity under them would be impossible, and if every man were a rule unto himself civilisation would crumble and fall to pieces."

The author considers that a long step towards the acceptance of compulsory arbitration would be achieved if profits were limited, and in considering the whole difficulties, he comes to the conclusion that a dividend on a company's invested capital should not exceed a specified figure. But he adds the important provision that "if the profits earned exceed the sum necessary to pay this dividend, 50 per cent. of the surplus might be retained by the company for the express purpose of extending plant and buildings or for any other project directly connected with the development of the productive power of the concern. The sums so spent should be looked upon as additional capital, and accrue to the shareholders in proportion to their holdings. The remaining 50 per cent., or surplus profit, would absolutely revert to the State." He contends for a more rigid control of prices of food and raw materials, his arguments being based on the theory that the cost of production should determine the selling price rather than the laws of supply and demand. "To take away (by limiting profits) from the supplier of raw material and the shipper of finished product all inducement to charge exorbitant rates and freights is one of the surest ways of increasing the prosperity of the general manufacturer. To increase our product and lessen the price at which we can produce is the most certain way in which to develop overseas trade and to promote the interests, men and masters alike, of that large bulk of our industrial community whose prosperity depends upon it."

We heartily commend the book, not only for its practical reasoning, but for its high moral tone, the concluding chapter, on moral responsibility, affording matter for serious reflection, as it stimulates a higher conception of the functions of citizenship, alike on the part of employers and employed.

BOOKS RECEIVED.

Evolution or Revolution; A Problem of Forces. By IRONICUS. London: The Cursitor Publishing Company. [Price 3s. 6d.]

Modern Coking Practice. By J. E. CHRISTOPHER, M.S.C.I., Wigan Coal and Iron Company. *Including the Analysis of Materials and Products.* By T. H. BYROM, F.I.C. Vol. I, *Raw Materials and Coke.* Vol. II, *By-Products.* Second Edition. London: Crosby Lockwood and Son. [Price 15s. two vols.; sold separately.]

Engineering Mathematics; A Series of Lectures delivered at Union College. By CHARLES PROTEUS STEINMETZ, Ph.D. Third Edition, revised and enlarged. London: Hill Publishing Company, Limited. [Price 15s. net.]

The Institution of Gas Engineers—Transactions, 1917. Edited by WALTER T. DUNN, Secretary. London: E. F. and N. Spon.

Victorian Railways; Report of the Victorian Railways Commissioners for the Year ended June 30, 1917. Melbourne: A. J. Mullett, Government Printer.

South Australia; Annual Report of the South Australian Railway Commissioner for the Year 1916–17. Adelaide: R. E. E. Rogers, Government Printer.

Western Australia; Report of the Department of Mines for the Year 1916.—Perth: F. W. Simpson, Government Printer.

The Guide to South and East Africa, for the Use of Tourists, Sportsmen, Invalids, and Settlers. Edited by A. SAMLER BROWN and G. GORDON BROWN. Twenty-fourth Edition. London: Sampson Low, Marston and Co., Limited; Cape Town, Port Elizabeth and Johannesburg: J. C. Juta and Co. [Price 1s. net; Post Free 1s. 5d. (U.K.).]

Hand Grenades: A Handbook on Rifle and Hand Grenades. By Major GRAHAM M. AINSLIE. First Edition. New York: John Wiley and Sons, Inc., London: Chapman and Hall, Limited. [Price 6s. net.]

Lockwood's Builder's, Architect's, Contractor's and Engineer's Price Book for 1918. Edited by R. STEPHEN AYLING. With a *Supplement* containing the London Building Acts, 1894–1909. London: Crosby Lockwood and Son. [Price 4s. net.]

Tables Numeriques Usuelles a l'Usage des Ingenieurs, &c. Par L. ZORETTI. Paris: Gauthier-Villars and Cie., 55, Quai des Grands-Augustins. [Price 3 francs.]

COMPANIES' ACTS, 1908–17.—The President of the Board of Trade has appointed a committee to inquire what amendments are expedient in the Companies' Acts, 1908–17, principally having regard to circumstances arising out of the war, and of the developments likely to arise on its conclusion, and to report to the Board of Trade and to the Ministry of Reconstruction. The secretary to the committee is Mr. W. W. Coombe, M.B.E., and all communications intended for the committee should be addressed to him at 55, Whitehall, London, S.W. 1.

THE STATE OF CHINA FROM AN ENGINEERING POINT OF VIEW.

(*Concluded from page* 221.)

TOWN-PLANNING in China has not been studied in any way. As a rule there are two main streets running from the north and south and east and west gates, with innumerable alleys running off these at all angles and of all widths. There are, of course, no building regulations, with the result that the buildings are a medley of types, irregular and straggling in every way. In the north, where carts are universal, the main streets are as much as 20 ft. wide, some not paved at all and full of enormous mud holes, others with the abominable stone-block paving mentioned previously. South China cities having no cart traffic, have streets at most 10 ft. in width, with the consequence that sanitary conditions are even more indescribable than in the northern cities. As a rule, much of the space within the city walls is not built up, but used for market garden purposes, so that most cities give rather a good impression from a distance.

With regard to the question of house building, those of the coolie class are always of one storey, and have walls about 1 ft. 6 in. thick, made of a mud and straw brick, with a flat arched roof of mud carried on round poles covered with millet stalk. The front of the house usually faces south, openings—which are built up in winter—being provided in the northern walls for coolness in summer. The windows used are similar in principle to the old leaded windows of the seventeenth century, but the frames are of wood and the size of pane about 4 in. square. Glass is not used, but in winter thin paper is pasted over the whole window. The floors of the houses are of mud, and are, of course, never cleaned, which, among other reasons, probably accounts for the appalling prevalence of tuberculosis as the Chinese expectorate freely wherever they are.

The houses of the poor are not as a rule warmed, in any way, but in the north, where 50 deg. of frost is not uncommon, the flue from the fire which is used for cooking purposes, passes beneath a raised platform or "kang" which runs along one side of the room which is thus warmed more or less. On the "kang" the whole family sleep huddled together for warmth, and to this custom and lack of ventilation is ascribed the awful mortality which occurred, when the pneumonic plague swept North China in 1912. The fuel used in these stoves is not as a rule coal, but either millet stalk or dried weeds which the younger members of the family spend an arduous day in grubbing up.

In the south, where the rainfall is much greater, the houses of the poor are roofed with thatch, while those of the better class have tiles. In both north and south the houses of the rich are built of the aforementioned soft porous brick with a tiled roof. The pitch of the roof is usually about 45 deg., and its weight is taken in the case where trusses are employed by timber struts built into the brickwork of the side walls. The form of roof truss employed is extremely clumsy, as well as heavy. These roofs are very picturesque, the tiles being often of a beautiful green or copper colour, while the ridge of the roof generally takes the form of a dragon (double headed) carried out in tiles.

The houses of the wealthy and the temples are somewhat similar in plan consisting of a series of courtyards one behind the other, the principal rooms being built at the head and foot of these courtyards, while quarters for servants and other inferiors occupy the sides. The most pleasing feature of these enclosures is the fine trees and flowers of which the Chinese are extremely fond, but the lack of any sanitary sense generally mars every pleasing effect. Better-class houses have now discarded the "kang" and use cast-iron coal stoves of American make or type.

The homes of rich and poor alike strike the Western eye as unfurnished and absolutely comfortless, cheerless, ill-ventilated and frightfully insanitary. Very many of the richer Chinese have adopted Western notions of furnishing, &c., but the adoption of the foreigner's idea seems in most cases to have involved the loss of that æsthetic sense which is usually shown, even now, in most of

their own productions. The Chinese home furnished in foreign style is usually a collection of "horrors" and incongruities.

For lighting both streets and houses kerosene oil is almost universally used. All of this oil is imported, the trade being practically in the hands of the Standard Oil Company, of New York, who imported 90,000,000 gallons in 1914, out of a total of 124,000,000 gallons, practically the whole of the balance being imported by the British-owned Asiatic Petroleum Company. Oil and the cigarettes of the British American Tobacco Company are the only foreign products sure to be encountered in the remoter parts of China, but these are obtainable from the sea to the Tibetan border, in the deserts of Mongolia and in little-known Turkestan. In this connection, it should be pointed out that there should be a great market for the very cheapest form of lamp, this trade is at present largely in the hands of the Japanese, and takes the form of dangerous glass abominations. It is by no means fully developed. The necessity for cheapness for any article manufactured for the coolie class is easily realised when it is considered that a man will bring up a family on an average wage of from 10*s.* to 12*s.* monthly. If a market can be created by foreigners to supply the simple wants of this class there is undoubtedly money in it.

For instance, a very cheap but lasting and waterproof form of shoe would undoubtedly appeal to this class, as what is worn now possesses neither of these qualities and is not cheap. The cheapest form of waterproof clothing would also perhaps find a good market, as the Chinaman as a rule has only two lots of clothes, the blue cotton summer ones and the heavy cotton-wool padded winter clothes. These are not interchangeable, so if once wet through clothes have to dry on the person, making the coolie very strongly object to doing any form of work in rainy weather. The difficulty about manufacture for the coolie market is the question whether any country except China itself has labour cheap enough to produce articles for such a poor class. India is perhaps the one country which could manufacture profitably for China.

Street lighting other than by kerosene is rare in China, but about 60 cities in the country have electric light, provided by foreign and Chinese companies. In connection with the electric light schemes there are electric trams in the cities of Hong Kong, Shanghai, Peking and Tientsin. Hong Kong, Shanghai and Dairen also have gas companies. Street lighting by kerosene, where attempted, is badly done, the lamps being badly cared for and spaced too far apart, with the result that most people carry lanterns, the usual procedure in most towns, the majority of which are still without any organised system of lighting.

Of the other necessities of civilised life most of the larger towns have notice newspapers of their own the majority of which are filled with rumours without foundation and other matter of doubtful nature. Practically all the larger cities are in telegraphic communication with the capital, but there are only 612 telegraphic stations in the whole country. Only 16 towns have a telephone service.

As regards public health, living under the conditions described above, it follows that any epidemic spreads with great rapidity. There are no public health regulations of any kind, no quarantine system, or notifiable diseases, with the consequence that people, while still infectious from small-pox or scarlet fever, move about quite freely. There are now mission hospitals run by foreigners in a large number of towns, but as the Chinese only go to the foreign doctor as a last resort, and often when on the high road to recovery suddenly take it into their heads to consult their own doctors, with disastrous consequences, much of the work of these institutions is either too late or vitiated by stupidity.

The study of modern medicine is not popular with the Chinese. Largely owing to the desire to make money quickly and to the absence of any regulations as to length of training before practice, very few of the students of the medical colleges, of which there are three, wait for proper graduation. They prefer to leave after a year or two, with a dangerous half-knowledge, to set up in practice in some city in the interior, where foreign criticism will not be encountered.

However, in spite of poor physique and the appalling conditions under which they live, the fact remains that the Chinese coolie is one of the hardest in the world. He can live and work in any climate and is equally at home in arctic Mongolia and Siberia, or in the heat of Java, Singapore or India. He is not so liable to dirt diseases, and it was proved in Panama under the French that he was the least attacked by malaria.

With regard to the question of newer industries, modern shipbuilding and the other departments of mechanical engineering have received very little attention. There are 23 shipbuilding and engineering works on the coast, of which three only are Chinese property. Of all these works, only three build ships, the remainder confining themselves to repairs and general engineering work. There are about 12 railway works in the country, but with the exception of those belonging to the Peking–Mukden and Shanghai–Nanking Railways, the shops are employed on general maintenance work, and very little outside work done. All machinery used is imported, as is also all steel for structural purposes. This market was in the hands of Great Britain and Germany before the war, the latter dealing principally in electrical machinery. In this department Germany had attained a paramount position, largely owing to the long credit system and curious notions of commercial morality, and also by the employment of men with a thorough knowledge of the country, who did not stick to the treaty ports, but went to look for orders. Lately Japan has begun to compete in all branches of this trade.

The kindred subject of shipping accommodation has been very little studied, all the initiative in this respect lying with the foreign communities, or with departments of the Chinese Government under foreign control. Thus the conservancy of the troublesome rivers on which the ports of Shanghai, Tientsin and Newchang lie, is to all intents and purposes in foreign hands.

Owing to cheap labour loading accommodation in the shape of wharfs is very poor, with the exception of the ports of Shanghai, Tientsin and Dalny, and the privately-owned port of Chingwangtae. Of these, Tientsin can only take vessels drawing 15 ft. of water. In other places, lighters are used entirely. All coaling is done by coolie labour. The only purely Chinese harbour improvement schemes are those at Chefoo, in Shantung, and Hulatae in the province of Manchuria. The last scheme has been abandoned half-finished owing to lack of money.

Minerals in China.

The following is a list of the minerals known to exist in China proper and Turkestan, with the principal places of production in brackets :—

(*a*) Kansu province.—Coal (Kungchangfu); iron, gold, silver, copper (Yaokai); petroleum.

(*b*) Shensi province.—Coal and iron (Sianfu); salt, gold, nickel, magnetite, marble and porphyry, petroleum (Yenchang).

(*c*) Shansi province.—Coal and iron (Taiyuanfu, Pingtingchow, Tsechow); salt.

(*d*) Honan province.—Coal and iron (Tsinghuachen, Lushanhsien and Juchow); tin and argentiferous lead ore.

(*e*) Chihli province.—Coal (Western Hills, Peking, Kaiping, Lanchow, *&c.*); Kaolin and sandstone, gold (Jehol).

(*f*) Shantung province.—Coal (Weihsien, Poshan and Ichowfu); iron (Kiulingchen); copper, argentiferous lead ore, gold (Chaoyuan, Pingtu and Weihaiwei); diamonds, gypsum, clay and sandstone.

(*g*) Szechuan province.—Salt (Tzulinching, Chiating and Paoning); coal and iron (Kuanhsien, Weiyuan, Chienwei, Ch'ichiang, Pahsien, Chiangpeiting); copper (Ningyun); white copper (Huilichow); silver, gold, petroleum (Pahsien and Wanhsien); lead, antimony, sulphur, saltpetre, gypsum, jade, mica.

(*h*) Hupeh province.—Coal (K'ueichow, Wuchang, Hsiangyangfu); iron and zinc, gypsum (Yingcheng); copper (Chienshih).

(*i*) Hunan province.—Coal (Siangtan and Valley of Hsiang River); gold (Huitung, Mopin); silver, iron (Anhua and Paoking); copper, lead (Changning and Chiyang); zinc, antimony (Anhua, Sinhua, Shaoyang and Shenchow); sulphur (Tzuli); realgar.

(*j*) Kiangsi province.—Coal (Pinghsiang and Lohpinghsien); kaolin, copper (Kanchow).

(*k*) Anhui province.—Coal (Ningkuofu and Chihchow); iron (Hoshan); copper (Tungkuanshan); lead.

(*l*) Kiangsu province.—Coal, iron, marble, plumbago (Kaotze, Chinkiang).

(*m*) Yunnan province.—Copper (Tungchuan and Chaotungfu); zinc, lead, tin (Kochiu); orpiment, coal (Talifu); salt, gold, gypsum, jade.

(*n*) Kueichow province.—Quicksilver (Pehmatung, Wuchuanhsien, Singyifu); iron, coal, copper, zinc, sulphur, marble.

(*o*) Kuangsi province.—Antimony (Szecheng); coal (Hohsien, Nanning and Yunnan); gold, silver, iron (Kuangyang); lead (Fuchuan).

(*p*) Kuangtung province.—Coal (Shaochoufu, Huahsien); iron, copper, lead, silver, tin, gold (Ch'inchow).

(*q*) Fukien province.—Coal, lead, tin, gold, silver, iron (Kutien).

(*r*) Chekiang province.—Coal (Chuchcowfu); lime, gypsum, alum (Pingyang); building stone.

(*s*) Manchuria.—Gold (Valley of Amur River); coal, (Liaoyang, Fushun, Yentai); iron (Tiehling); silver, copper, lead, asbestos, soda.

(*t*) Singkiang (New Dominion or Chinese Turkestan).—Gold, lead, coal (Turfan); sulphur, saltpetre, alum, petroleum, jade.

There is only one Chinese steamship company of any size, the bulk of the coasting and river trade being carried on in junks whose draught never exceeds 10 ft., and for which very little harbour accommodation suffices. These junks are top-heavy looking, wood built, with huge sails, rather resembling the ships of the Elizabethan era. Their tonnage does not exceed 800 tons, but they are amazingly well handled considering their clumsiness and make quite lengthy voyages. The lighting of the Chinese Coast is in the hands of the Chinese Maritime Customs, a Government department under international supervision, and meets all modern requirements.

Turning to the question of mines and mining, the accompanying list taken from the "China Year Book" for 1916, gives some idea of the colossal mineral wealth of the country. This wealth has been hardly touched for a variety of reasons, of which superstition is perhaps the principal one, the outrageous royalties demanded by local officials from the smaller Chinese companies another, and the absurd mining laws the last. This law stipulates, among other irksome conditions, that not more than 40 per cent. of the capital of any company shall be of foreign origin. Another law, which militates against the advancement of the country is that by which only missionaries may own land, and that for purely non-industrial purposes. China in this and every other field has tried to shut out foreign capital, presumably for protective reasons, pursuing in this way a somewhat similar policy to that of Turkey with her dependencies and Portugal with her African colonies. This capital is a necessity as a limit to petty tyrannies and obstructions from which all purely Chinese concerns suffer at present.

Foreign capital and methods are particularly necessary for the mining development of the country, as the native methods are always limited by the fact that there is no method of coping with water in any quantity, or any suitable hoisting machinery. So far as is known the Chinese never used suction pumps, but remained content with a crude form of wooden chain pump worked by hand. These can be put in series, of course, but the slip is enormous, and in any case they are quite unsuitable for mining purposes. Water wheels are also used for irrigation purposes, but they are very primitive in design. On this account most native workings are mere surface scratches. Native methods of smelting and refining are also excessively crude and wasteful.

As for the present condition of this industry, only coal-mining has received any modern attention. Thus there are six foreign and nine Chinese mines owning modern machinery and worked on up-to-date lines. These are responsible for the bulk of the coal output, which amounted to 9,500,000 tons in 1916.

There are also four modern steel works in the country, all of which are now controlled by the Japanese, who take most of the ore and the manufactured product as well.

A few mining concessions have been granted to foreign firms, but in practically every case such opposition has been encountered locally as to make working impossible. These concessions have then been cancelled by the Central Government by payment of compensation, a most futile and uneconomical proceeding, as nothing is ever done in the direction of development by the people themselves. The only concession so far seriously exploited has been that of the Standard Oil Company for the petroleum of the provinces of Shansi.

Unfortunately the results were disappointing, and the project was abandoned.

The majority of the copper mines in the country are worked by native methods, but two or three Chinese companies own some modern machinery.

Agriculture, the calling of the vast majority of the people, is carried on in the same antiquated manner as most other industries in the country. This may be partly due to necessity and lack of capital, but much is due to ignorance and conservatism. For instance, no land ever lies fallow, the use of fertilisers is unknown, the only method of enriching land being to dig out the rich soil from the stream beds and spread over the land. The plough used is merely a glorified shovel which scratches the soil to a depth of about 6 in.; all reaping and binding is done by hand, the methods of threshing are those of the Bible, as are those of sowing, harrowing, &c. These are the methods born of necessity and, in some degree, lack of capital, but ignorance is responsible for bad methods of cattle and horse breeding, fruit growing, the exhaustion of the land consequent on the disregard of the principle of rotation of crops, and the wholesale destruction of timber for fuel purposes. This destruction of timber more especially at the head waters of rivers, has had disastrous effects not only on the climate, but on the rivers themselves, making them liable to quick flooding and change of bed, with awful consequences to the people in the vicinity. In the province of Yunnan forest burning goes on every year for no apparent reason. A forestry department with plenary powers is one of the most urgent needs of the country, as is also an instructional department in modern agricultural methods.

From the above short summary, it can be realised how backward China is, but her achievements in the past and undoubted power to repeat them, given good government, should also never be forgotten. As previously stated, the immediate cure for China's ills is not education but better communications. It should also be stated that in certain of the southern provinces, more particularly Kwantung and Fuksin, the standard of wealth is higher than would be gathered from the above. This is largely due to the presence of emigrants returned from the Federated Malay States, Philippines, &c., or to people living on the pay of emigrants.

SUBSTITUTES IN THE GERMAN ELECTRICAL INDUSTRY.

THE search for substitutes in this country since the war began has been mainly directed to the replacement of German manufactured articles. We were suddenly cut off from a great part of our supplies of dyes, lenses, synthetic drugs, the rarer metals, and many other things, and had to provide them for ourselves. Up to the end of last year we did not suffer greatly from want of raw materials, and our present scarcity is largely due to our supplying the needs of our Allies. In Germany, the case was different, for the blockade acted mainly against the entrance of raw materials. It is, of course, far more difficult to replace a raw material than to inaugurate a new manufacture for which the materials are available. The straits to which the German electrical industry have been reduced have lately been pourtrayed before a meeting of the Swedish Electricity Works by Chief Engineer M. T. Husberg. He had a sympathetic audience, for Sweden has been very badly hit in the same way, and this has happened when the great hydro-electric stations were not completed, and were specially wanted on account of the high price of coal.

The Germans, as soon as war had commenced, took up the question of substitutes in their usual systematic way, and the electro-technical industry may be said to have taken the lead in this connection. As early as the latter portion of 1914, when the Government requisitioned copper, rubber and other raw materials, special commissioners were appointed to deal with these matters. To obtain any suitable substitutes at all it was often necessary to fall back upon other materials which were not by any means plentiful, although less scarce than the usual materials. The first task was accurately to ascertain the quality and adaptibility of the possible substitutes, and to what extent the normal regulations had to be altered and the normal demands modified.

The greatest difficulty which the electrical industry had to face in Germany was the shortage of copper and its alloys. The comparatively small quantity of these metals which could be produced within the country had, almost entirely, to be reserved for military purposes. Also the supply of aluminium has been somewhat limited, large quantities being needed for the construction of aeroplanes and other war munitions. Also of lead, nickel and tin there has been a very considerable shortage; zinc has been fairly plentiful, as have also iron and steel. Endeavours have, therefore, been made to use zinc instead of copper, where iron was out of the question, and only to use aluminium where zinc could not be used. The following table contains some particulars as to the qualities of the metals in question :—

—	Conductivity.	Specific Gravity.	Melting-point in Deg. C.	Coefficient of Thermal Expansion per Deg. C.
Copper	57.0	8.9	1,084	1.7×10^{-5}
Aluminium ..	32.7	2.7	657	2.2×10^{-5}
Magnesium ..	22.0	1.7	630	3.2×10^{-5}
Zinc	16.0	7.2	420	3.0×10^{-5}
Electron—				
Cast	16.0	1.8	620	—
Pressed ..	16.0	1.8	620	—
Iron	7.0	7.8	1,400	1.2×10^{-5}
Steel	5.8	7.7	1,350	1.2×10^{-5}

The electro-technical industry had so exclusively confined itself to copper conductors, with some slight use of aluminium, that before the autumn of 1914 the practical adaptibility of the other metals had hardly been investigated. Up to that time such metals as zinc and magnesium had not been produced commercially as wire. The Germans at once began to investigate the best possible methods of production, and within a comparatively short time, they achieved very notable results. Nevertheless for many purposes copper remained indispensible.

Zinc was first taken in hand, and both its natural unfavourable qualities and the difficulties of manufacture were reduced. The manufacture of drawn zinc wire was soon attained, and its brittleness and sensitiveness to change of temperature to some extent reduced. The purest metal was selected and it was shaped in the first instance by a squirting process. Under a pressure of as much as 500 atmospheres the zinc was extruded in a cylindric shape, which was afterwards drawn into wire. At first, zinc bars were made by cutting them out of rolled plate, but by squirting and pressing bars of improved qualities were obtained. Although zinc conductors still have a relatively low strength and a low melting-point, they prove a practicable substitute for certain purposes, such as bus-bars, conductors and apparatus, and in some cases even for machine windings. In many cases, however, the low conductivity of zinc makes it unfit to serve as a substitute for copper. Its ductility is fairly satisfactory, inasmuch as wires of 1 mm. to 3.5 mm. in diameter can be bent 20 times over a rod before breaking. Soldering of zinc is difficult, and must be done cautiously, as its melting-point is still lower than that of aluminium.

Aluminium was already, before the war, so widely used that its qualities and the most efficient method of manufacture were fairly well known, as were also the difficulties and drawbacks connected with its use, such as its low tensile strength and somewhat low melting-point. Yet aluminium, whose conductivity is twice that of zinc, is a really valuable substitute for copper in the construction, both of conductors, machines and apparatus. Even before the war, in the year 1913, the world's consumption of aluminium for conducting purposes was estimated at 10,000 tons per annum. Since then the mode of manufacture has been improved, amongst other ways by a careful cleansing of the raw material, so that both overhead lines and windings of a considerable increased flexibility are now produced.

Moreover, several alloys of aluminium have been further investigated and improved, and new alloys have made their appearance. In this connection mention should be made of electron (10 per cent. aluminium, 90 per cent. magnesium), magnalium (90 per cent. aluminium, 10 per cent. magnesium) and duralumin (91 per cent. aluminium, 9 per cent. copper). These alloys, besides pure magnesium, whose conductivity lies between that of zinc and aluminium, are principelly used for bus-bars and heavier bar connections, and as castings in apparatus for high voltage. For purposes where an entirely non-magnetic material is required, electron is much used.

The Germans have made extensive use of iron for electric conductors, and have made elaborate researches to reduce its drawbacks arising from its small conductivity, the troublesome skin effect with alternate current transmission if the lines are too thick, and its tendency to rust if the lines are too thin. Special wires have been formed with a core of steel and outer layers of better conductors. Much attention has also been given to different methods for protecting iron wire, first and foremost by zinc, but in some cases also by a copper coating. Such coatings serve for the conductor in insulated lines.

As the three most important metals—aluminium, zinc and iron—began to be more extensively used as substitutes for copper in electric conductors, it was proposed to introduce the word "kaze," as a reminder of the four metals, copper (Kupfer), aluminium, zinc and iron (Eisen) ore being numbered in the proper order, and that each metal has a conductivity that is very roughly double that of the subsequent one.

In insulating materials the shortage has been most pronounced in rubber, cotton, jute, oil, asbestos and mica, and a number of more or less satisfactory substitutes have been produced and put to the test. Paper, first and foremost, has been extensively used in different forms and compositions. It has been spun into yarn and impregnated. It takes the place of jute and hemp in underground cables, and replaces cotton and rubber on transmission wires and in coils. A more valuable substitute for rubber has been found in regenerated rubber, that is, refined rubber residue. This substitute is improved in certain works by being amalgamated with bitumen or other tar substances which make it elastic. A substitute for hard rubber is furnished by an artificial product of phenol and formaldehyde, called Faturan. It is not hygroscopic and can, it is asserted, be compounded so as to be fireproof and acid-proof. Other similar substances are wenjacite and aswelite, the latter having been brought out by the Siemens-Schuckert Company. As a substitute for oil in electric apparatus the firm of Voigt and Haeffner have brought out what they call Benzinoform, a tetra-chloride-carbon substance, which will not burn, but the experiences so far have not been quite satisfactory, inasmuch as the material is too volatile.

As regards the practical uses to which the different substitutes referred to above, have been put in Germany during the war, the subjoined table throws some light upon the position before the war and at present :—

Appliances.	Substances Used. Before the War.	At Present.
Overhead conductors	Copper wire ..	Iron wire.
		Composite iron and zinc.
		Composite iron and aluminium.
		Aluminium and paper, &c.
Insulators and insulated conductors	Hemp, jute.. ..	Conductors with paper insulation and iron, zinc or aluminium conductors.
	Ordinary vulcanised conductors, single or otherwise	Rubber insulated zinc or aluminium conductors.
	Flexible for movable connections	Flexible iron wires.
	Cables, with or without armouring, with vulcanised rubber and lead covering	Cables with paper insulation and thinner lead covering.
Apparatus such as lamp-holders, switches, safety appliances, &c.	Copper, brass, tombac	Iron, zinc, aluminium.
Resistances ..	Copper, nickeline ..	Manganine, iron, water resistances.
Bus-bars	Copper	Iron, zinc, elektron, magnesium.
Machines	Copper and cotton ..	Zinc, aluminium, iron, paper yarn.
Belting	Leather	Paper, steel bands.
Lubrication ..	Oil	Graphite oil, solution with potash.

All the above new substances have been subjected

to auxiliary regulations and alterations in the German *Verbandsnormalien*.

For overhead conductors iron is principally being used. With alternate current and over large areas, when stranded wires have to be used, the separate wires in the cable are not as a rule of less diameter than 1.5 mm., for fear of them rusting through, nor of more than 3.00 mm., so that the skin effect may not be too serious. The method of manufacture plays an important part as regards diminishing the skin effect, and the hardness of the steel, or the iron, is also of some moment, inasmuch as the skin effect is reduced with an increased strength. If, however, the metal is too hard, the specific resistance is increased.

Special regulations, based upon careful tests, have also been proposed for composite conductors. The outer layer, outside the galvanised steel wire, is mostly made of zinc wires, and such conductors have worked exceedingly satisfactorily. With alternate current they have but slight skin effect, as shown by some special tests; an iron conductor of 70 sq. mm. area was compared with a composite conductor of 50 sq. mm. area; both had about the same Ohmic resistance; at 70° the former had 39 per cent. increase in resistance, the latter 22 per cent. Firms like Felten and Guillaume and the Bergmann concern have taken up the manufacture of these conductors with areas from 2.5 sq. mm. to 150 sq. mm. Composite conductors with an outer layer of aluminium naturally show a better conductivity, and they are resorted to when the iron-zinc cables are no longer adequate. Such conductors have also been used in America for some years with good results.

Overhead conductors of zinc alone are not likely to be used, although zinc wires of best quality have proved serviceable with very short distances between the poles. If iron or zinc conductors are laid under ground, they must be lead-coated or in some other way protected against corrosion. The regulations prescribe a number of precautions to be observed at the junctions of overhead conductors, especially as regards connections between wires of different metals.

Insulated Lines.—As early as December, 1914, the first regulations were drawn up concerning the method of manufacture of insulated wires, to remain in force until further notice. These regulations applied to insulated conductors and the wires, other than copper, were to be of aluminium or flexible tinned, galvanised or lead-coated iron, with a conductivity at least 7. Single conductors were not to exceed an area of 16 sq. mm., and stranded conductors an area of 6 sq. mm. for each wire. If of copper or aluminium they might be solid up to 16 sq. mm. area; if of iron up to 2.5 sq. mm. area. Multiple conductors were to comprise a minimum of seven wires of 1.4 mm. maximum diameter. The conductors were to be surrounded with a well-impregnated paper cover of from 0.8 mm. to 1.2 mm. thickness, according to the cross-section of the conductor. Outside the paper coating was to be spun a covering of cotton, hemp, &c. The surface cover was to consist of a non-corrodable metal envelope (not lead) of at least 0.25 mm. thickness. Insulated conductors of this description were only to be used for low voltage and in dry premises, where they were to be visible. Insulated conductors, made in this manner, but fitted with a leaden envelope, might be used in damp premises, if fixed visibly. The current density on the iron conductors was to be about in the proportion of 1 : 2.8 to that permissible for copper.

In March, 1915, the regulations were altered for insulated wires with paper coverings, inasmuch as zinc was admitted as a conducting material, zinc being allowed to be used solid up to 16 sq. mm. area. The smallest permissible areas were then modified to be 1 sq. mm. for copper and aluminium, 1.5 for zinc, and 2.5 for iron.

The coated conductors, however, could not in all respects serve as substitutes for the ordinary vulcanised lines, which soon became more and more scarce from shortage of copper and rubber. Regulations were therefore published, also in March, 1915, for conductors of zinc with an insulating layer of a rubber composition, to be used for low-voltage installations on fixed apparatus. This rubber was manufactured with the greatest care from regenerated products. Inasmuch as regards elasticity and durability, this material cannot vie with ordinary valcanised rubber, it was ordered, to begin with, that the layer should have a thickness of at least 1.5 mm. instead of 0.8 mm. These "rubber-insulated" conductors are, when solid, of 1.5 sq. mm. to 6.0 sq. mm. areas, and when multiple, of 1.50 sq. mm. to 150.00 sq. mm. areas. The conductivity must be at least 15.

Some time later it was announced, that in spite of many applications iron could not be admitted in the above-mentioned conductors, because the wires were so stiff, and damaged the regenerated rubber insulation. Only zinc, of the most pliable kind (besides copper and aluminium) can therefore be used for the new "rubber conductors." The minimum thickness of the rubber layer was at the same time reduced.

In August, 1915, it was arranged with the manufacturers, that all conductors of zinc and regenerated rubber should have a light green marking thread, so that they could be known from ordinary vulcanised wires. For flexibles the insulating cover could be made of regenerated rubber and the conductor of fine iron wire, with a cross-section from 2.5 sq. mm. to 4.0 sq. mm.

In the beginning of 1916 it was announced that when insulating tubes of paper were enclosed in an unwelded tube, the latter might be covered with zinc instead of lead, the zinc coating to be thick. Regulations for aluminium conductors in rubber-insulated lines followed in March, 1916, both for stationary and movable purposes. In September, 1916, when the shortage of raw materials had become still more pronounced, it was prohibited to use outer coverings of cotton on "rubber insulated" zinc and aluminium conductors of 16 sq. mm. or more, permission being at the same time given, for similar conductors, to have an inner paper-yarn coating round the separate wires instead of rubber-impregnated windings. At the same time the demands as to copper were modified, so that its resistance might amount to 20 ohms per kilometre of 1 sq. mm. section at 20 deg. C., corresponding with 19.6 ohms at 15 deg. C., instead of 17.5 ohms as otherwise used.

That the current density in insulated conductors of substituted metals is relatively high will appear from the following table, which shows that stranded conductors indoors, protected by 6 A safety fuses, if of copper may have an area of 1 sq. mm., if of aluminium also 1 sq. mm., if zinc 1.5 sq. mm., and if of iron 2.5 sq. mm. :—

Load in Amperes.

Area in Square Millimetres.	Copper. Strength of Current.		Aluminium. Strength of Current.		Zinc. Strength of Current.		Iron. Strength of Current.	
	1.	2.	1.	2.	1.	2.	1.	2.
	amp.	amp.	amp.	amp.	amp.	amp.	amp.	amp.
1.0	11	6	8	6	—	—	—	—
1.5	14	10	11	6	9	6	—	—
2.5	20	15	16	10	11	6	8	6
4.0	25	20	20	15	13	10	10	6
6.0	31	25	24	20	16	10	12	10
10.0	43	35	34	25	23	20	17	15
16.0	75	60	60	35	40	35	30	25
25.0	100	80	80	60	52	35	—	—

1 represents the permissible current; 2 the normal current.

Many warnings have been uttered against these conducting materials, however pressing the reasons have been for adopting them. On the whole, however, experience appears to have been favourable, and the fact that the regulations for these new types have been laid down by the Society of German Engineers offers in itself a guarantee for their safe use. Tests show that zinc conductors, principally on account of the larger quantity of material required for the same strength of current, are not exposed to any greater risk of melting than are copper wires.

Installation Material and Instruments and Apparatus.—Substitute metals have proved very serviceable for instruments and apparatus. It has already been mentioned that zinc, aluminium and its alloys are well suited for bus-bars and fittings. Iron, too, has been used for such purposes, but in such cases the bars must be divided in a suitable manner, when dealing with alternate current. Iron and zinc are now normally used for lamp-holders, wall contacts, cable shoes, switches A, for safety apparatus up to 350 A, starting and regulating resistances up to 100 A, &c. As regards starting resistances, water has again come into vogue.

When the metals referred to do not possess sufficient conductivity, aluminium is resorted to as a substitute. All movable parts of contacts and contact arrangements with springs exposed to light arcs, however, must be of copper or be coated with copper or a copper alloy. Zinc and aluminium have too low a melting-point for such purposes.

As regards switches and other apparatus for the instrument house, where it is a question of currents of considerable strength, the experiences of the last year show that, even in such, iron and zinc can often with advantage be used in the principal parts. Separate regulations have been drawn up for special metals to be used as substitutes in the various meters and measuring instruments.

Machines and Transformers.—The Germans first tried zinc in transformer windings and afterwards also in machine windings, and iron was used in commutators. A standardised machine manufacture with such substitute parts is now in full operation. Experience has shown that compared with equally large normal machines of copper the following substitutes develop :—

	Per Cent. Efficiency.
Transformers with zinc windings	60
Three-phase motors	40–60
Continuous-current machines, with field winding of zinc, commutator of iron, and armature winding of copper	80
Continuous-current machines, with both windings of zinc and commutator of iron	50

All machines with substitute metals naturally have relatively low efficiency, in the same way as three-phase motors have a lower load factor :—

Machines up to about 1,000 Revolutions.	Stator Winding.	Rotor Winding.	Slip-ring or Commutator.
Asynchr., three-phase motor (100 volts to 5,000 volts)—			
Below 0.3 kw.	Copper	Copper	—
From 0.3 kw. to 10 kw. ..	Aluminium	Zinc or Aluminium	Iron
From 10 kw. to 80 kw. ..	Zinc.	Zinc.	Iron
From 80 kw. to 175 kw...	Aluminium	Aluminium	Iron
Above 175 kw.	Aluminium	Optional	Optional
Synchr. three-phase machine (100 volts to 5,000 volts)—			
Up to 70 k.v.a.	Zinc	Zinc	Iron
From 70 k.v.a. to 250 k.v.a.	Aluminium	Aluminium	Iron
Above 250 k.v.a. ..	Optional	Optional	Iron
Continuous-current machine (100 volts to 500 volts)—			
Below 2 kw.	Copper	Copper	Copper
From 2 kw. to 10 kw. ..	Aluminium or Copper	Copper	Iron
From 10 kw. to 35 kw. ..	Aluminium	Aluminium	Iron
From 35 kw. to 175 kw...	Zinc or Aluminium	Aluminium	Iron
Above 175 kw.	Aluminium	Copper	Copper

Three-phase Transformer up to 30,000 volts.	Windings according to Voltage.		
	Up to 15,000 volts.	15,000 volts to 20,000 volts.	20,000 volts to 30,000 volts.
Capacity up to—			
15 k.v.a.	Aluminium	Aluminium	Aluminium
15 k.v.a. to 25 k.v.a.	Zinc	Aluminium	Aluminium
25 k.v.a. to 50 k.v.a.	Zinc	Zinc	Aluminium
50 k.v.a. to 250 k.v.a.	Zinc	Zinc	Zinc
Above 250 k.v.a.	Aluminium	Aluminium	Aluminium

Of late the supply of aluminium in Germany has been on the increase, for which reason, in order to improve the machines, windings of this metal have been adopted in some cases. In machines and transformers made in this way, the efficiency is stated to be only 20 per cent. short of the normal. The above tables show the German regulations for the use of substitutes in machines and transformers. Where it is a question of machines for special purposes and whose reliability of working is of particular importance, the normal mode of manufacture may still be used. Machines and transformers with copper or aluminium windings are, according to the new regulations, allowed to rise

CONTINUOUS MILLING MACHINE.

CONSTRUCTED BY THE BECHER MILLING MACHINE COMPANY, HYDE PARK, MASS., U.S.A.

(For Description, see opposite Page.)

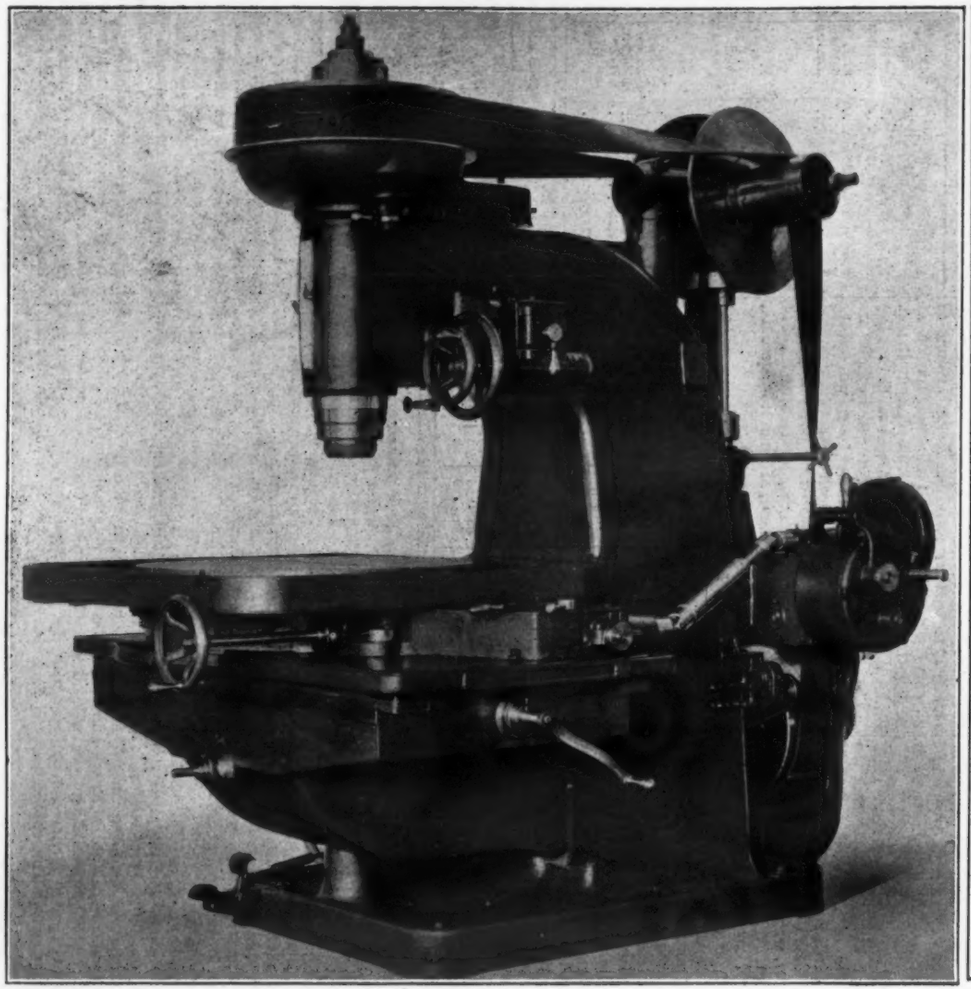


FIG. 1.

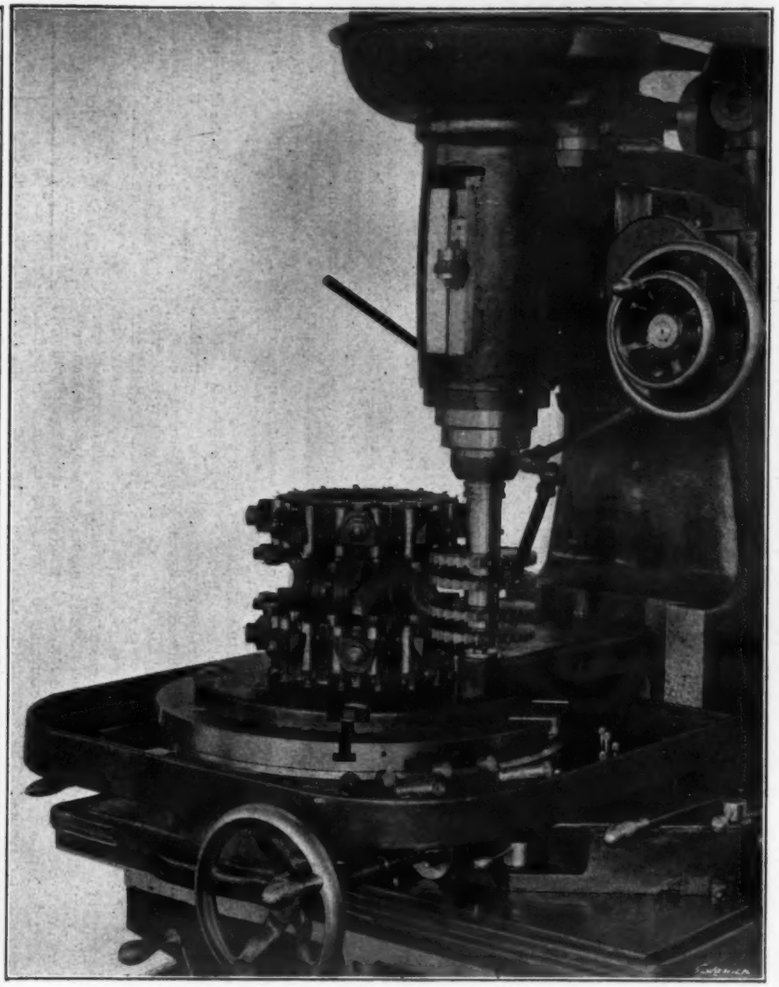


FIG. 2.

to a temperature 10 per cent. higher than that which was normally permitted.

For insulation impregnated paper yarn is extensively used instead of cotton.

Ball bearings have been generally adopted so as to save the expensive copper alloys for the usual bearings, and so as to reduce the consumption of lubricants.

The different German commissions dealing with the matter of substitutes in the electric industry continue to publish regulations and directions. There are also new regulations for overhead lines tending, in some respects, to increase the permissible strain on the constructive parts; also for the use of different substitutes in instrument transformers of various kinds. Based upon the most recent experiments the regulations as regards materials for conductors, especially zinc conductors, have been revised, both for insulated and bright lines. The Imperial Postal Department has materially modified the regulations hitherto in force as regards crossings between high-voltage lines and telegraph or telephone lines.

It will be gathered from what has been said

CONTINUOUS MILLING MACHINE.

CONSTRUCTED BY THE BECHER MILLING MACHINE COMPANY, HYDE PARK, MASS., U.S.A.

Fig. 3. SECTION A. A. THROUGH ROTARY TABLE, TABLE SUPPORT & KNEE

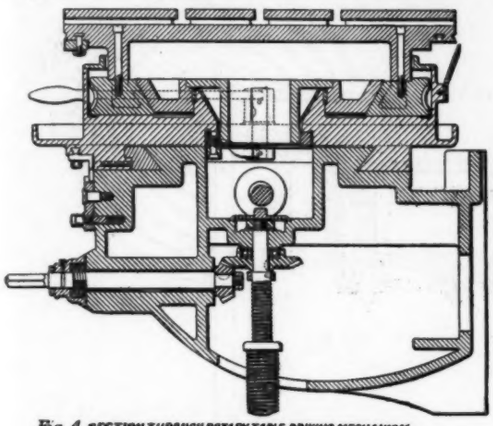


Fig. 4. SECTION THROUGH ROTARY TABLE DRIVING MECHANISM.

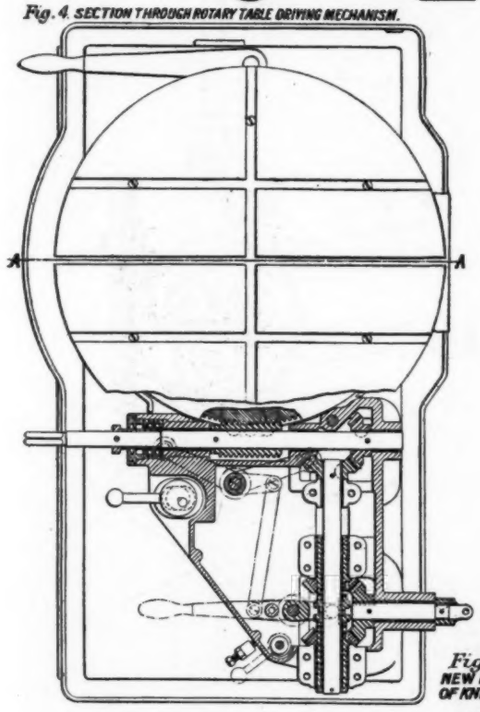


Fig. 6.

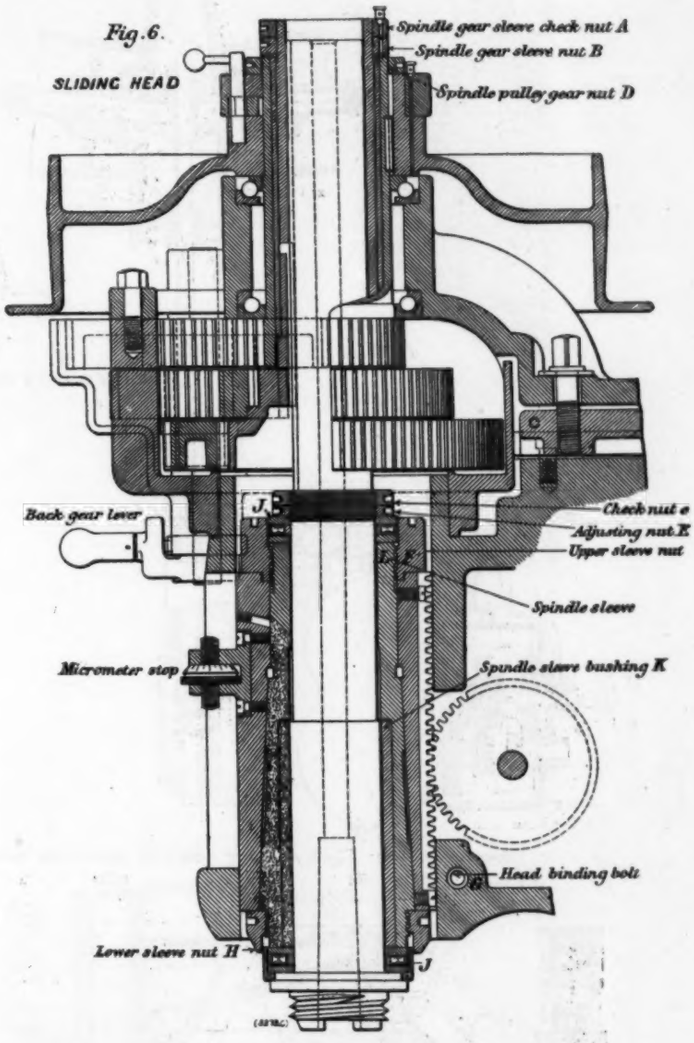
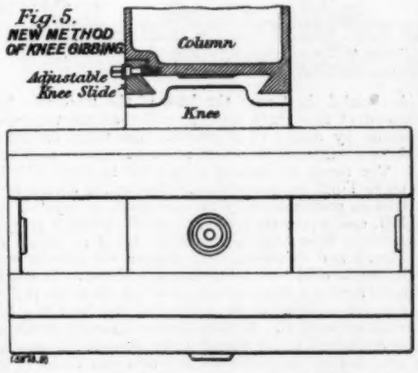


Fig. 5. NEW METHOD OF KNEE GIBBING.



above that substitutes have become of the greatest importance to the German electric industry, and the point of special interest is to be found in the fact, that the use of substitutes has become so extended, although it has been carefully regulated by special rules. The representatives of the high-voltage transmission seem to have found out, to their own surprise, that in many cases satisfactory results could be obtained by means of materials, which they would never have thought of employing before the war. It has, however, in some ways been comparatively easy to carry on all these tests in a thoroughly rational manner, inasmuch as the question of cost has not been much considered during the war. Satisfaction has, on several occasions, been expressed at old-rooted prejudices now having been overcome, prejudices which formerly unnecessarily increased the cost of electric plant and equipment.

Another point should be mentioned in connection with the electric industry in Germany during the war. In spite of the serious shortage of the old, and for the matter of that, though to a smaller extent, some of the substitute raw materials, the electricity industry has worked, if anything, with increased energy. From the standpoint of national economy it is more advantageous to produce energy on a large scale for the really necessary requirements, than to produce it in isolated heat motors and to use gas or petroleum for lighting.

In conclusion, we beg to express our indebtedness to M. Chief Engineer Tore Husberg for the information embodied in this article.

CONTINUOUS MILLING MACHINE.

We illustrate on the opposite and present pages, and pages 250 and 251, a continuous milling machine constructed by the Becher Milling Machine Company, of Hyde Park, Mass., U.S.A. The machine has been designed to secure a continuous operation of the cutters, without pause for the removal of finished pieces or for putting fresh ones into place. Whilst the cutters are at work on one piece the attendant is able to replace a finished piece by a new blank. Since with ordinary tools the time required to fix work in place preparatory to a cut is often much greater than that required for the actual cutting operation, special fixtures are provided by which the slow tentative adjustment of the work is dispensed with, the blank being clamped into the proper position straight away.

General views of the tool are reproduced in Figs. 1 and 2, page 248. The work table, which is 41½ in. in diameter, is supported on a knee moving on vertical guides cast solid with the main column of the machine. The traverse provided for is 20 in., and may be effected either by power or hand. The table has a longitudinal traverse of 42 in. either by hand or power as well as a rotary motion. A plan and cross section of this table are reproduced in Figs. 3 and 4, annexed. The rotating portion is, it will be seen, given a wide flat bearing on the cam slide which carries it, and to this it is held down by an internal cone as shown. The rotary motion is provided for by a worm which can be thrown completely out of gear if it is required to shift the table round through a large angle by hand. A revers-

CONTINUOUS MILLING MACHINE.

CONSTRUCTED BY THE BECHER MILLING MACHINE COMPANY, HYDE PARK, MASS., U.S.A.

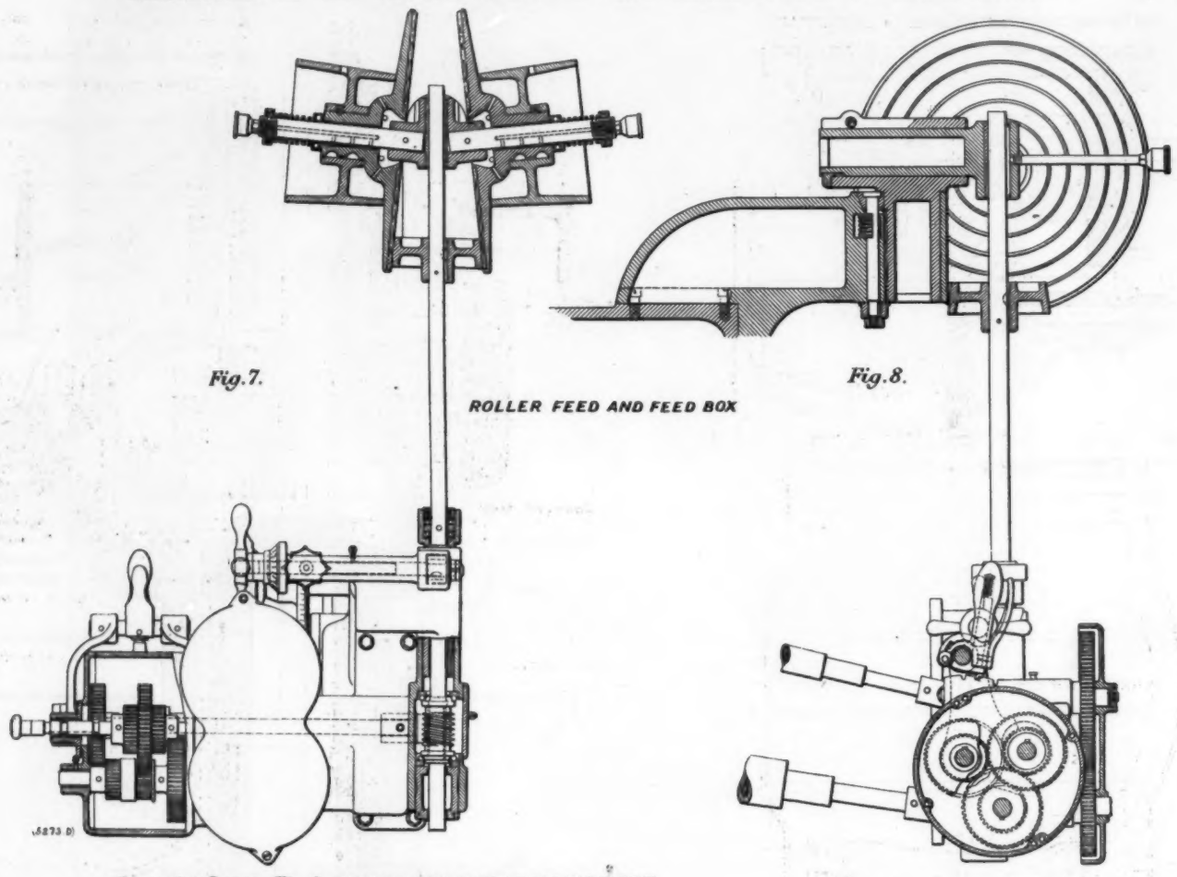


Fig. 7. *Fig. 8.*

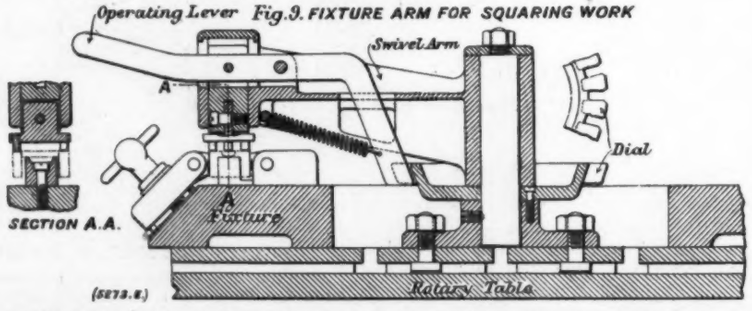


Fig. 9. FIXTURE ARM FOR SQUARING WORK

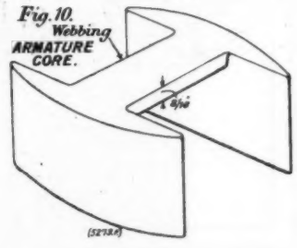


Fig. 10.

ing motion of the bevel gear type (see Fig. 4) enables the table to be fed round in either direction.

The elevating screw shown in Fig. 3 is used only for making rough adjustments in the level of the table, and when this is approximately correct the knee is firmly clamped to its guides on the main column by the wedge shown in Fig. 5. The fine adjustment in the vertical direction is effected by raising or lowering the cutter spindle by the rack motion shown in Fig. 6. The range of motion provided for is 13 in. At its lower end this spindle is supported by a bronze bushing 4 in. in internal diameter which is, in its turn, gripped in a second bush, which fits into a conical hole bored in the sleeve to which the adjusting rack is fitted. This sleeve is provided with an adjustable micrometer stop which in combination with distance pieces makes it possible to adjust the cutter level with the greatest precision.

The cutter drive is effected by means of a wide belt passing round a pulley near the top of the spindle. This pulley is keyed to a sleeve which embraces the spindle sleeve and is supported by ball-bearings at top and bottom. Back gears which can be thrown in or out of action by the simple movement of a lever enable extra heavy cuts to be made when desired.

The belt driving the spindle passes over two guide pulleys down to a driving pulley and mounted on a horizontal shaft near the base of the machine. The speed of this shaft can be varied within very wide limits by means of a gear-box the range extending from a minimum of 8 r.p.m. to a maximum of 270.

The range of feeds provided for is from ·003 in. up to 1·021 in. per minute. The feed is driven by a friction gear formed by the two guide pulleys for the belt, and a cone on a vertical spindle which is gripped between them, the arrangement being as shown on Figs. 7 and 8, above. The grip on the friction cone is provided in part by the springs shown. It will be seen, however, that the axis on which the guide pulleys run are inclined to be horizontal and that the belt seats are conical. As belts have a tendency to mount to the largest pulley diameter, the effect of this arrangement is that the pull of the belt also contributes to the grip on the friction cone, which is thus more tightly gripped the greater the pull on the belt. The bracket which carries the belt pulleys is, as shown in Fig. 8, adjustable both vertically and horizontally, so that a tight belt is always readily secured. The vertical shaft carrying the friction cone passes through a sleeve near its lower end. This sleeve has a rack cut on it, by means of which the shaft and the friction cone can be elevated or lowered, the end motion of the shaft being prevented by ball bearings. The higher the position of the cone the slower the rate at which the vertical shaft rotates. Back gearing arranged in the box shown near the bottom of the shaft enables further reduction of speed to be made. The final drive for the feeds is transmitted through telescopic shafting fitted with Cardan joints, as indicated in Fig. 8.

Several forms of work holders are illustrated in Figs. 11 to 13, page 251. These are specially designed for the work in hand. Fig. 11 represents a type used in machining small connecting rods, whilst in Fig. 12 a fixture used for holding fan pulleys, during the operation of having the joint faced, is shown. The attachment illustrated in Fig. 13 is used for work of a lighter character, viz., armature cores having the form shown in Fig. 10, above.

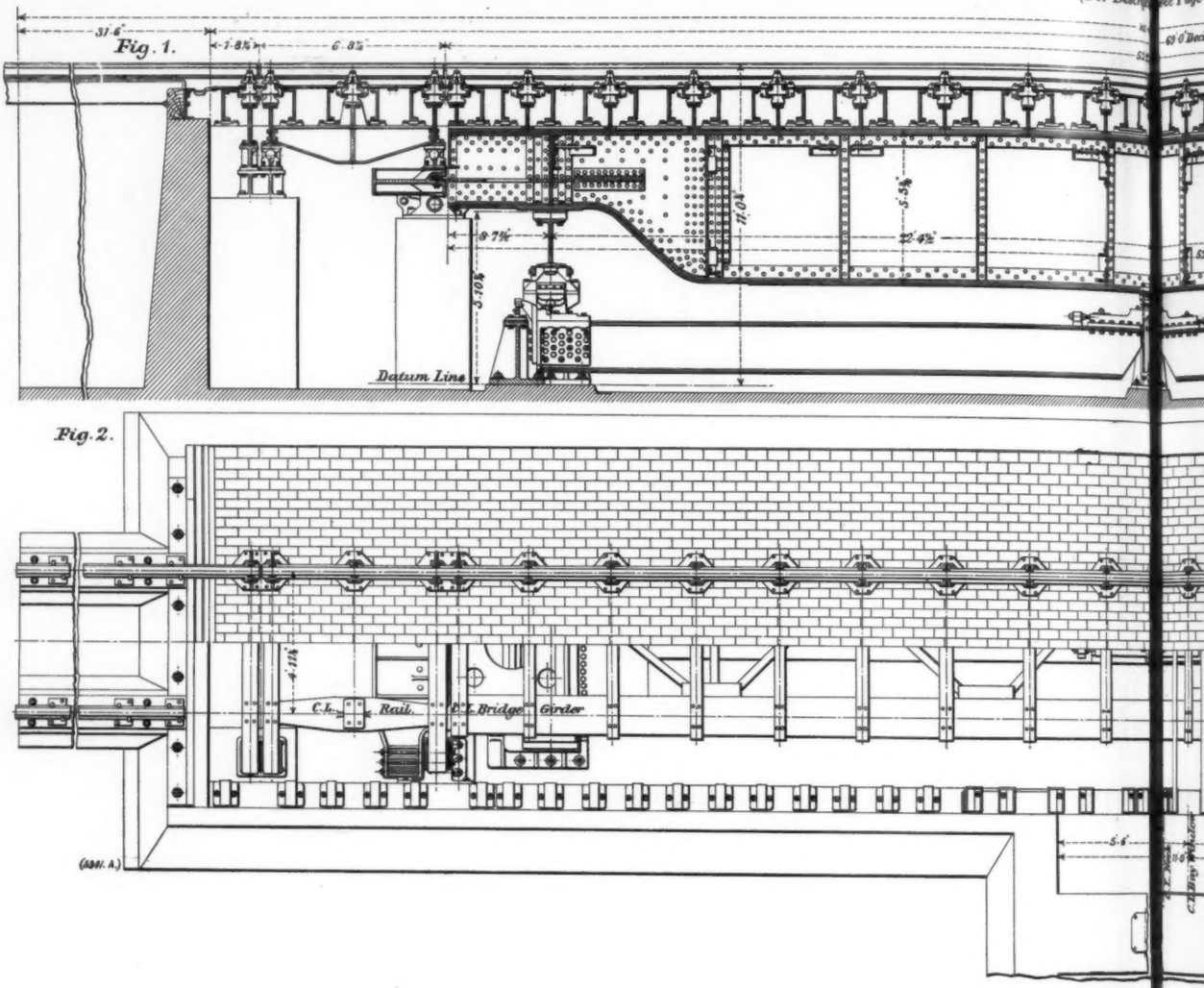
The bridge strip here is only $\frac{3}{16}$ in. thick and had to be cut square to the sides and flat and parallel within $\frac{1}{1\,0\,0}$ in. To facilitate the accurate location of these articles in the milling fixture the arrangement shown in Fig. 9 was employed. The operating lever is used to hold down the blank firmly on its seat whilst the clamp is being tightened.

For the larger class of work the makers of the machine recommend the type of cutter represented in Fig. 14, page 251, whilst smaller cutters may be made on one piece as shown in Fig. 15. It will be seen that the tooth spacing is large, thus facilitating the clearance of the chips.

PLATE FULCRUM TRACK WEIGHBRIDGE FO TH

CONSTRUCTED BY MESSRS. E. AND T. FAIRBANKS ND CO

(For Descri ee Page



FIGS. 1 AND 2. ELEVATIO D PLAN

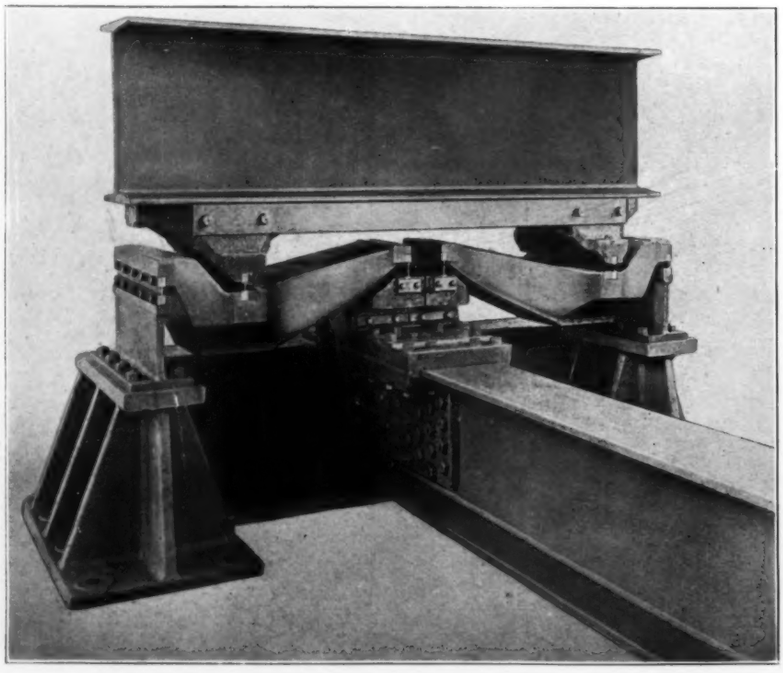


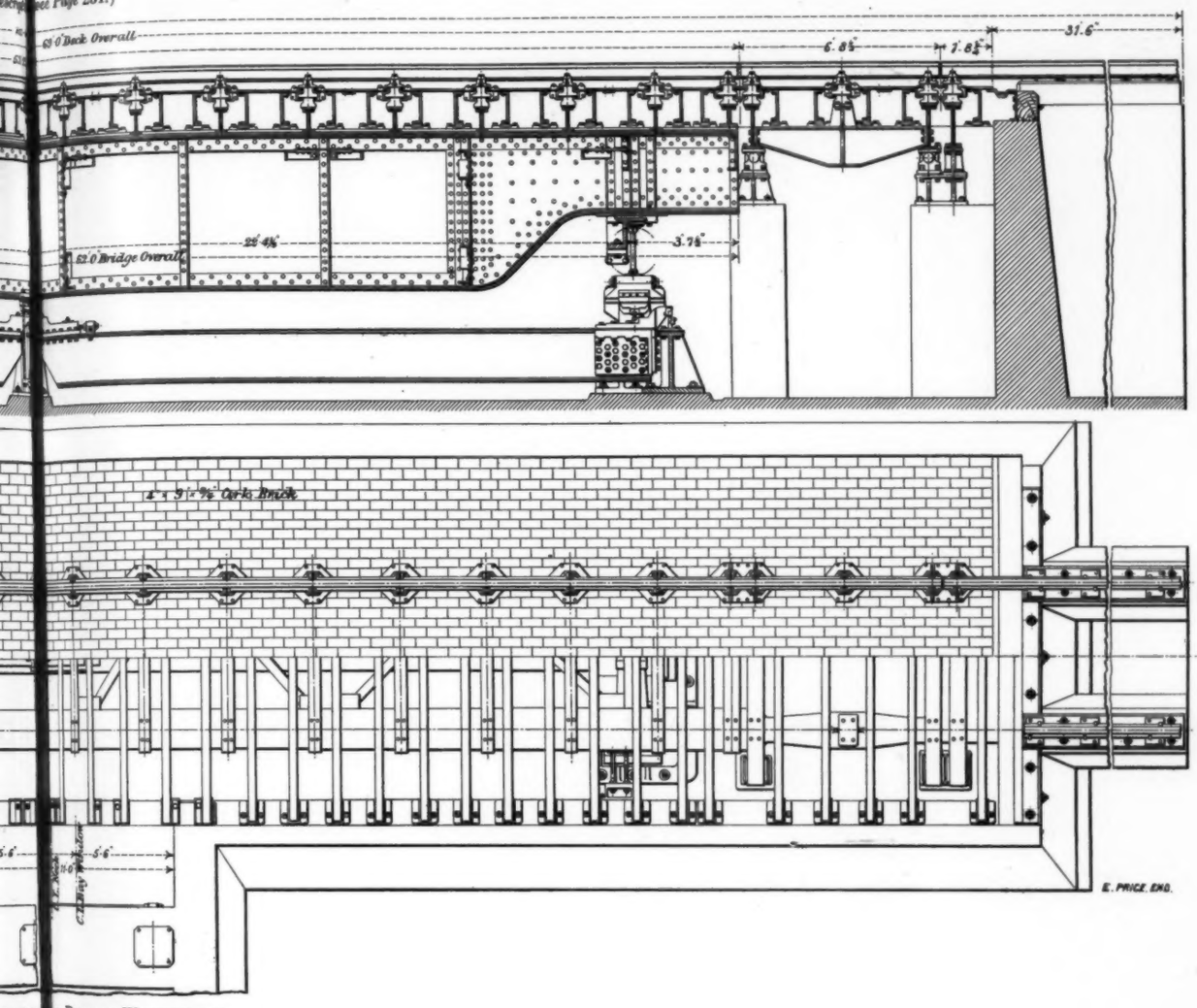
FIG. 3. MAIN LEVERS AND LONGITUDINAL EXTENSION LEVER AT FIXED END.

FIG. 4. JUNCTION OF THE LONGITUDINAL L WITH T

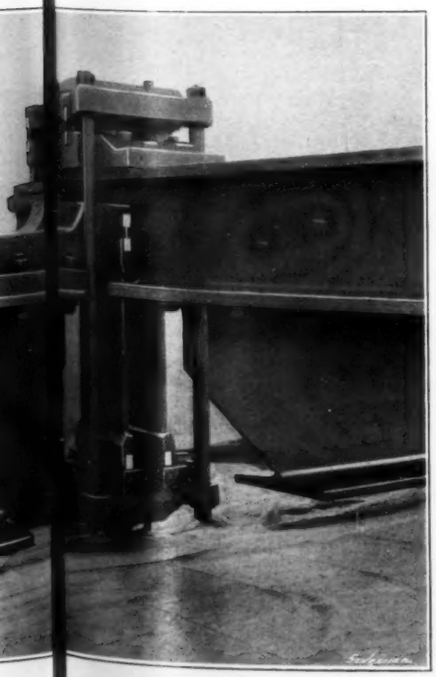
THE PENNSYLVANIA RAILROAD COMPANY.

ND CO., ENGINEERS, ST. JOHNSBURY, VT., U.S.A.

ee Page 251.)



LEVATION AND PLAN OF WEIGHBRIDGE.



DINAL LEVER WITH THE TRANSVERSE EXTENSION LEVER.

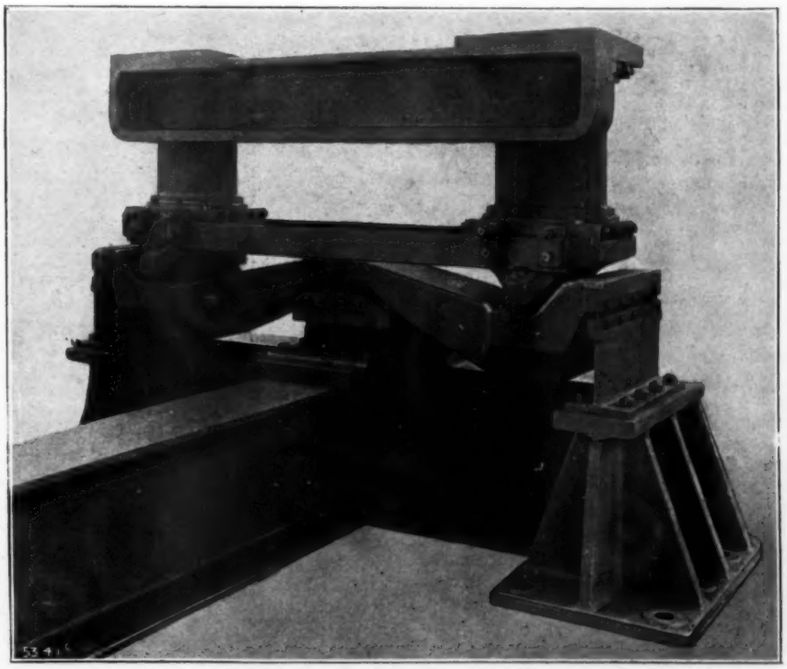


FIG. 5. MAIN LEVERS AND LONGITUDINAL EXTENSION LEVER AT MOVABLE END.

DETAILS OF CONTINUOUS MILLING MACHINE.

CONSTRUCTED BY THE BECHER MILLING MACHINE COMPANY, HYDE PARK, MASS., U.S.A.

(*For Description, see Page 249.*)

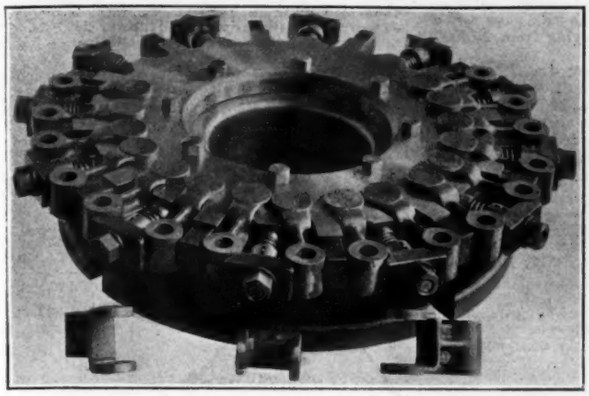


FIG. 11.

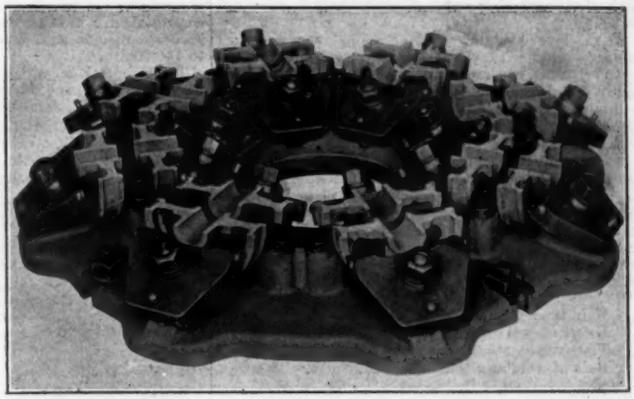


FIG. 12.

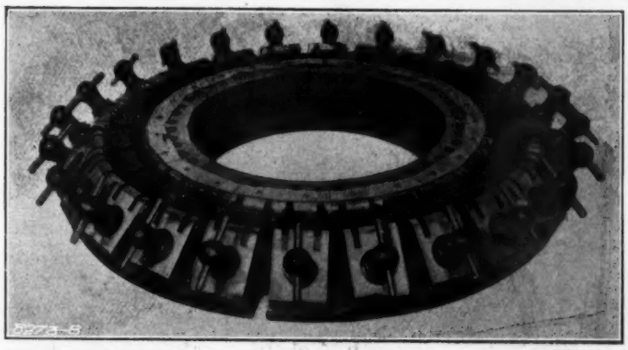


FIG. 13.

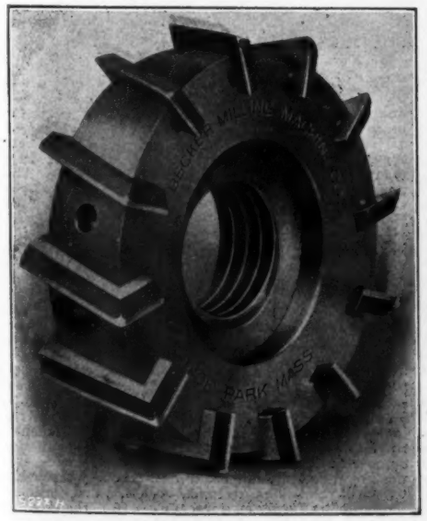


FIG. 14.

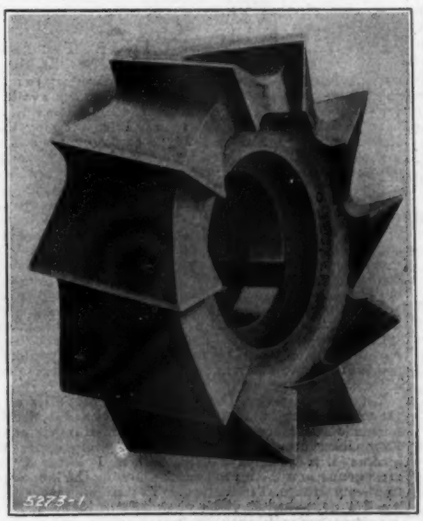


FIG. 15.

PLATE FULCRUM TRACK WEIGHBRIDGE.

WE illustrate in Figs. 1 to 5, on Plate XXIV, and in Figs. 6 to 10, on page 258, a railway weighing machine, one of the main features of which, as will be seen, consists in the substitution of plate fulcrums for the customary knife-edges and bearings hitherto provided in machines of this class. The complete installation is shown in the elevation and plan, Figs. 1 and 2, Plate XXIV, which give the principal dimensions of the machine. It is erected as part of the track in a concrete pit, the foundations and walls of which are heavily reinforced with twisted bars. The inside length of the pit is 69 ft. and the inside width 10 ft. The height from the top of the three inner foundation piers to the base of the track rail is 10 ft. 6 in., whilst the distance from the centre line of the bridge to the centre line of the weighing beam is 10 ft. The effective weighing bridge has a total length of 52 ft. overall. An approach span is provided at each end, supporting a short section of rail which is independent of both the main track and the weighing bridge. Figs. 3 to 5, on Plate XXIV, show the main levers and the longitudinal extension lever at the fixed end of the bridge; the junction of the two longitudinal levers with the transverse extension lever; and the main levers and the longitudinal extension lever at the movable bridge end; whilst Figs. 6 and 7, on page 258, illustrate respectively the levers assembled and one of the fixed approach spans.

These illustrations show the location of the plate fulcrums, one of which is given diagrammatically in Fig. 10, on page 258. They consist of a relatively thin central part connecting two heavier heads and are made from pieces of rectangular steel reduced to a thin web-section in the centre. The steel used is a high-grade chrome-vanadium steel, having a tensile strength of 200,000 lb. per square inch. The thin, central part, forms the plate and gives the desired flexibility, whilst the heads distribute the load in the supporting members and decrease its intensity, supplying at the same time a ready means for attachment to the levers and the supporting stands. The thin central part is arranged to act in direct compression and is subjected to a slight flexure as the weighing beam vibrates and the lever system responds to the condition of balance. With this construction, the wear, and subsequent inaccuracies, are eliminated in the vital parts of the weighbridge.

The main bridge consists of two plate girders, one on each side of the extension levers. They are 5 ft. 5⅛ in. deep in the central portion, reduced to 2 ft. 7 in. where they are supported on the main lever sections. The girders are securely tied together by means of transverse and diagonal bracing, to form a very rigid bridge construction, which will effectively resist longitudinal and lateral strains. The steel cross-ties consist of 10-in., 35-lb. I-beams, securely riveted to the top flange of each girder. The rail stands are supported directly on the cross-ties. The main bridge is fixed at one end and free to move at the other. The fixed end of the bridge is supported by means of a transverse I-beam engaging directly with the bearing castings, and the movable end is supported on cast steel struts provided with hardened steel inserts, ground to a radius and engaging with hardened steel plates at their top and bottom surfaces. The lower plates are directly supported on two steel castings similar to those for the transmission of the load at the fixed end. The construction is shown in Figs. 3 and 5, on Plate XXIV. The main bridge is checked in the longitudinal direction by means of a stayplate 44 in. wide and 1 in. thick, reduced to ½ in. at each end so as to allow for flexure. This stayplate is secured to the girders by means of a heavy transverse connection, and is anchored to a cast steel transverse support which, in turn, is securely anchored to the foundation. Transversal checking is provided for by a substantial connection to the transverse supports at the movable end of the bridge, and is joined to a rigid support, attached to the side walls of the pit. The transverse checking device consists of two rods, 2½ in. in diameter, reduced to 1¼ in. at each end to provide for flexure. Compensation for expansion in the main bridge is

provided for. The approach spans, Figs. 1, 2 and 7, consist of 18-in., 70-lb. I-beams, supported on base-plates with spool bearing, which provides a means for the alignment of the approach rails with the weighing rail. The 18-in. beams in turn support a steel casting which furnishes a support for an intermediate rail stand under the approach rails. These rails are 6 ft. 8 in. long and are independent, as above stated, both of the weighing rail and of the rails in the main track.

In the lever system, the four main levers are steel castings, and each lever is arranged to support three plate fulcrums, as shown in Figs. 3 and 5, Plate XXIV, and in Fig. 6. The seats of the plate fulcrums are very accurately machined, so as to maintain the true theoretical distance between the centre lines of the plates and also to preserve their exact parallelism. The longitudinal extension levers are made of 20-in., 140-lb. girder beams, to which are fitted at the butt ends heavy castings for carrying the plate fulcrums. The transverse extension lever, Fig. 4 on Plate XXIV, and Fig. 6, on page 258, is a 10-in., 105.5-lb. I-beam, and is fitted at the butt end with a heavy steel casting for the support of the plate fulcrums. The multiplication of the levers is as follows :—

	Multiple.
Main levers	3¼
Longitudinal extension levers....	20
Transverse extension lever	11⅔
Butt of weighing beam	800

The connections between the tips of the main levers and the longitudinal extension levers are made by means of heavy steel castings, in which are machined recesses at right angles to each other for engagement with the heads of the plate fulcrums in the main levers and longitudinal extensions. The recesses in these castings are very accurately machined, so that the connection can be made without introducing any initial strains in the plate fulcrums, and also to obtain that the main levers and longitudinal extensions be exactly at right angles to each other. The castings are arranged so that in the normal position of the main levers there is a ¼ in. space between them in the transverse direction. The longitudinal extension levers are connected to the transverse extension lever by means of radial struts, having hardened, curved steel surfaces in the lower portion, which engage with hardened steel bearing plates supported in a platen which, in turn, is suspended by substantial rods from the bearing block engaging with the load plate in the transverse extension lever (see Fig. 4, Plate XXIV). The bearing plates are encased by housings which are designed so that they can be adjusted in the horizontal direction, as shown also in Fig. 4, by means of non-corrosive adjusting screws. This is necessary so as to enable the radial struts to be maintained in a vertical position should there be any adjustment of the longitudinal extension lever nose irons. The transverse extension lever is connected to the butt of the weighing beam by means of two suspension rods supporting a platen which, in turn, supports a radial strut connection directly attached to the end-plate fulcrum. In order to prevent any possibility of displacement at the ends of the longitudinal extension levers, a transverse stayplate is provided. This plate is attached at one end to the lever platen and is anchored at the other end to the base of the transverse extension lever baseplate. A stayplate is also provided at the tip of the transverse extension lever. In this way, the true position of all the extension levers is very accurately maintained.

The weighing beam is of open hearth steel, machined throughout. It is notched, fitted and scaled with the utmost care and is supported by means of plate fulcrums of the proper dimensions to give the requisite strength and flexibility to insure sensitiveness.

The plate fulcrums in the weighing beam are made of high-grade "blue strip" steel. The weighing beam is provided with an indicator which moves over a graduated scale. The general arrangement is shown in Figs. 6 and 8. A locking device is provided so that the beam can be securely locked when the weighbridge is not in operation; it consists of an eccentric which engages with a flat spring, and a pressure of 15 lb. is applied at the permanent beam stop. A stabilising weight is located exactly over the fulcrum, and is provided with vertical adjustment so that the period of vibration of the beam can be changed at will to suit local weighing conditions. Directly over the indicator fulcrum a small vertical weight is applied, having a screw adjustment in the vertical plane; this has the effect of changing the sensitiveness of the scale. An oil dashpot at the tip end of the beam steadies its motion. The main beam is gradnated to 300,000 lb. in 1,000-lb. notches, and the fractional bar to 1,000 lb. in 50-lb. notches. An auxiliary weight of 100,000 lb. can be applied at the tip of the beam to give a total weighing capacity of 400,000 lb. Fig. 9, page 258, shows the poise; it is on ball bearings and with centre indication. The pit is heated by means of a hot-water system, sufficient radiation being provided to maintain a temperature of 60 deg. A number of electric lights illuminate the pit, to allow complete inspection of the mechanism at all times.

On completion of the installation, the weighbridge was tested under varying increments of load from 25,000 lb. to 140,000 lb., both concentrated and distributed. There was no perceptible error. The action of the lever system under varying loads was remarkable and practically "straight line" calibration was obtained; in other words, the scale gave perfectly accurate results with loads varying from 25,000 lb. to 140,000 lb.

The weighbridge, which is erected at Pitcairn, Pa., was built by Messrs. E. and T. Fairbanks and Co., at their works in St. Johnsbury, Vt., and its development has been due to collaboration between them, the Pennsylvania Railroad Company and Mr. A. H. Emery, who has used the plate fulcrum principle in large testing machines for many years.

THE NATIONAL INDUSTRIAL RESEARCH LABORATORY.*

By SIR RICHARD T. GLAZEBROOK, C.B., D.Sc., F.R.S.

SOME seventeen years ago I spoke in this room on "The Aims of the National Physical Laboratory." I endeavoured to make clear the reasons for its establishment and to indicate some of the work we hoped to accomplish. I concluded: "It has been my wish to state in general terms the aim of the Laboratory to make the advances of physical science more readily available for the nation and then to illustrate the way in which it is intended to attain these aims. I trust I may have shown that the National Physical Laboratory is an institution which may deservedly claim the cordial support of all who are interested in real progress."

Much has happened since then: how far we can assert that we have made good is for others to say. At any rate, our growth and the generous aid we have been given by many valued friends is evidence that the support for which I asked has not been wanting. And now that another great change in our position is about to take place and, as I trust, a wider sphere of usefulness is offered to us, it is not unfitting to put on record something of what has been done and to indicate, though it must only be in general terms, plans for the future. "Plans for the future": to-day it is hard to plan; one thought only fills all our minds, and every effort is needed to secure that victory without which future plans are useless.

Let me commence, then, with a few statistics as to growth and work: In 1901 the staff consisted of three scientific assistants working in some small rooms at the Kew Observatory, and the old observatory staff; the income was perhaps 5,000*l.* When I lectured last arrangements were in progress for moving the laboratory to Bushy House, Teddington. To-day—or rather from April 1 next—we shall be organised in eight different departments, each with its own superintendent and a large staff of scientific assistants and observers. The staff now numbers well over 500 persons, of whom about 180 are women. The expenditure during the current financial year will be considerably above 100,000*l.* Quite recently several acres of ground adjoining the laboratory have been secured and large additional buildings are being erected; these are required for urgent war work.

Many of these have been erected by private generosity. Thus, Sir A. F. Yarrow gave 20,000*l.* for the William Froude National Tank, Sir Julius Wernher erected the Metallurgical Laboratory at the cost of 10,000*l.*, Sir John Brunner gave 5,000*l.* to the Electrical Laboratory, while many friends—including the Royal Commissioners of the Exhibition of 1851—contributed to the administration block (Fig. 1) and the Optical Laboratory erected in 1913 at a cost of 20,000*l.*

As to finance, it may be of interest to give some figures. The ordinary expenditure—excluding sums spent on capital account—increased from 5,479*l.* in 1900 to 38,003*l.* in 1913–14, the total income from January, 1900, to March 31, 1914, being 282,545*l.* The sources of this income were distributed thus :—

	£
Treasury grants to the laboratory ...	80,500
Treasury grants for aeronautics ...	20,182
Receipts for work done	166,633
Donations	15,230
	282,545

During the same period the capital expenditure was 156,198*l.*, provided thus :—

	£
From Treasury grants	75,941
From private donations	55,967
Provided out of income	24,290
	156,198

The enormous growth in expenditure from 38,000*l.* in 1913–14 to over 100,000*l.* this year is, of course, due to the war.

FIG. 1. THE ADMINISTRATION BUILDING.

The growth of the *personnel* has been already alluded to. On the Executive Committee the changes have been numerous. Of the original members, all of whom gave untiring work towards the promotion of our interests, we have lost Sir Courtenay Boyle, Sir John Wolfe Barry, Sir Edward Carbutt, Dr. Elgar, Sir Andrew Noble, Sir W. Roberts-Austen, and Sir Arthur Rücker, while, in addition, from the names of the original General Board the following are missing: Lord Kelvin, Sir William Huggins, Sir Michael Foster, Professor Ayrton Dr. L. Mond, Sir William Preece, Sir Joseph Swan, and Sir W. Wharton. Sir John Wolfe Barry's recent death will be felt as a severe loss, not only to the laboratory, where he was welcome as a wise counsellor and a real friend, but to all the numerous institutions with which he was connected. We are happy in having Lord Rayleigh still as our chairman; his hand has steered us through many difficulties, and to his consistent support much of the success is due.

During this period the ultimate control of the laboratory has rested in all particulars with the president and council of the Royal Society. They have been responsible for the finances of the institution. Any loss—I am glad to say there has been no loss—would have fallen on the funds of the society; the laboratory, in spite of its name "National" has really been a private concern of the Royal Society, supported most cordially throughout by six of the leading technical societies, and dependent for part of its income on a grant-in-aid from the Treasury, but in the main from the receipts from fees.

From April 1 next there is to be a change. The scientific control of the laboratory is still to be exercised by the president and council of the Royal Society; the property of the laboratory is to be vested in the Imperial Trust for the Encouragement of Scientific and Industrial Research,—it is now vested in the Royal Society. The income of the laboratory, including receipts from fees, is to be vested in, and is to be under the control of, the Committee of the Privy Council for Scientific and Industrial Research. The laboratory will be managed by an Executive Committee appointed as heretofore and containing representatives of the great technical societies. In this manner it is hoped to secure financial

* A lecture delivered at the Royal Institution on Tuesday, February 26. A second lecture, delivered on Tuesday last, March 5, will appear in our next issue.

stability and to retain at the same time the great benefits which have come from the close connection with the Royal Society.

In the future, as in the past, the laboratory will endeavour to discharge two functions; it will be a Laboratory of Industrial Research, and a National Testing Institution or Proving House. To-day we deal with the Laboratory of Industrial Research.

Industrial research—What is it? In recent years much has been written on this subject; the idea of a laboratory devoted to industrial research is by no means novel, and the steps by which ordinarily a scientific discovery develops into a manufacturing process are generally recognised. First and foremost we have the research student impelled by his thirst for knowledge, his desire to penetrate ever deeper into the mysteries of Nature; he does not work with the deliberate intention of making something of service to humanity. Faraday's discoveries of electromagnetic laws, made in this building, were at first as useless as the new born babe, but had within them that power and potency which has transformed the industry of the world. Röntgen, when he discovered X-rays, or J. J. Thomson when he tracked down ions and corpuscles in the manner he has often demonstrated here, thought little of their application to surgery and the countless benefits they have brought to suffering humanity.

There must be institutions where research work is carried on for its own sake, where—to apply Sir J. J. Thomson's recent remark—men may make discoveries which may revolutionise and not merely reform the world, where they may train students in those fundamental laws and principles which must be at the root of every successful endeavour to apply science to industry. But there is a wide gap between such homes of science and the works of the manufacturer, and it is to fill this that laboratories of industrial research are needed.

Abbe realised in 1876 that British optical instruments had reached the highest development possible until a radical change was made in the properties of the glass used for lenses; it took years of patient labour, aided by subsidies from the Bavarian Government, before he and Schott were able to place Jena glasses on the market. Von Bayer discovered synthetic indigo about 1880, but it was not till twenty years had passed that the Badische-Anilin-Soda-Fabrik produced it on a commercial scale. Long and patient inquiry was needed in the great laboratory of the General Electric Company, of America, at Schenectady before the Coolidge tube was developed from the original X-ray tube. The work of the discoverer needs development and extension before it can be utilised by industry. This is the task of the Laboratory of Industrial Research.

Or, again, looking at our problem from the opposite side, a manufacturer has some question to solve—the utilisation of a waste product which if it were not waste would make all the difference between commercial failure or success, the discovery of a material with some special properties—*e.g.*, a light alloy of great strength at a high temperature—needed before a new machine can be completed. Such a man must have access to a laboratory fitted and equipped for the purpose with a trained staff having stored experience as the result of previous work or researches on cognate questions. Let me try to indicate some of the methods in which the National Physical Laboratory has endeavoured to fulfil these duties.

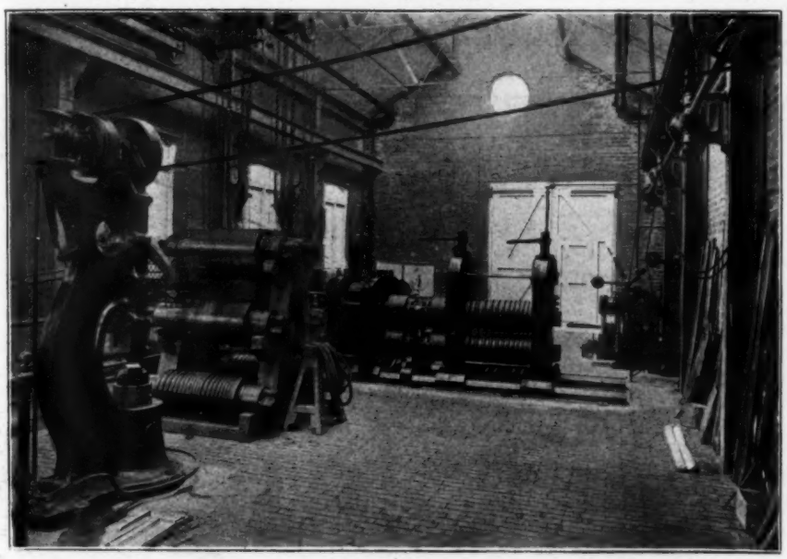


FIG. 2.

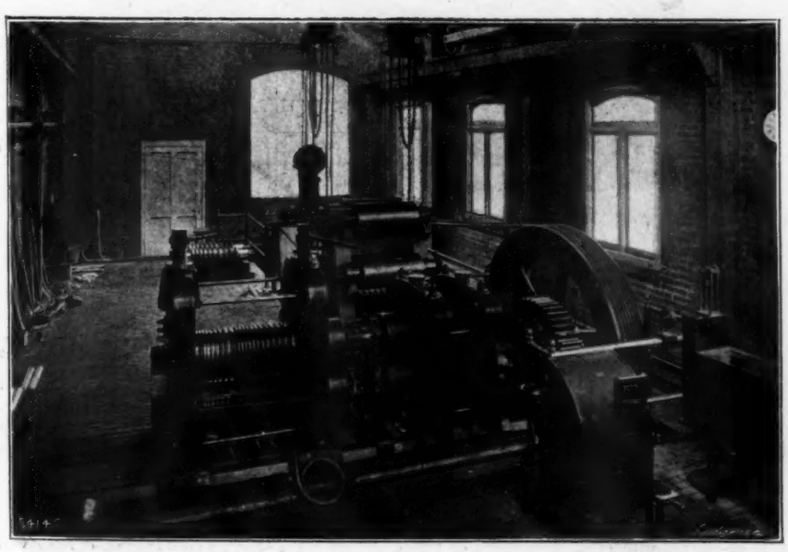


FIG. 3.

FIGS. 2 AND 3. THE ROLLING MILL.

Three of the researches referred to in my earlier lecture related to the production of optical glass, the work of the Alloys Research Committee of the Institution of Mechanical Engineers, and the measurement of wind pressure on various structures and surfaces. On all these subjects much has been done. It was some time before the authorities could be persuaded that in neglecting to study the production of optical glass in England they were adding seriously to the risks and dangers of war. Many years ago a strong committee, formed under the chairmanship of the late Sir David Gill, took the matter up and laid before the Government a scheme for a complete study of the problem. Nothing was done until war taught us the need of attending to key industries, but since then real advances have been made, not only at the laboratory but elsewhere also, and some of the more serious difficulties of the problem have been overcome; it is hoped that in the near future it may be possible to introduce changes of procedure which will greatly simplify the process of manufacture and lead to an increased output. Closely bound up with this is the study of the properties of refractory materials used in furnaces and elsewhere.

The application of the microscope to investigate the mechanical properties of metals and alloys was comparatively in its infancy in 1901 when I called attention to the then recent work of Professor Ewing and Mr. Rosenhain on slip-bands. At the laboratory the study of alloys, principally perhaps the light alloys containing large percentages of aluminium, has been almost continuously pursued first by Dr. Carpenter and now for some years past by Dr. Rosenhain. The various reports of the Alloys Committee of the Institution of Mechanical Engineers must be referred to by those who wish to estimate the importance of that work; it is not too much to say that nearly all the alloys of aluminium now used in the production of aircraft are its outcome. A list of the important papers dealing with this subject presented to the Advisory Committee for Aeronautics would fill many pages of this lecture and our knowledge has been immensely increased thereby. It must not be inferred from the foregoing that the metallurgy of the light alloys is the only branch of the subject which has been studied at the laboratory. A large number of "special investigations" have gone in the various departments. By the term "special investigation" is implied some inquiry into a particular subject made at the instance, maybe, of a Government department or of a private firm, *e.g.*, the investigation into the properties of a new material or the cause of failure of some machine or process such as a boiler plate, the crankshaft of an engine, or an autogenous weld. For example, the failure of one of the main roof trusses of Charing Cross Station some years ago led to an interesting inquiry into the strength of welds. Thus, certain aspects of the metallurgy of steel have received very full consideration.

But it is sometimes urged: "Why do you need a special laboratory for such work? Can it not be done equally well in one of the university or technical college laboratories? Is it not enough to multiply and organise these, to bring the teachers into direct contact with the manufacturers of their districts, and to encourage the students at an early stage to interest themselves in the scientific problems they will have to solve later in their daily work?" To this my answer would be that it is not enough. The primary work of the professor is to teach and to advance knowledge, that of the student is to learn how to research and to apply his knowledge. The professor will, no doubt, keep in close contact with the industry and take his illustrations from the manufactures of his district, but before his students can usefully engage in industrial research they must have a thorough grasp of the principles underlying all research and of the methods of employing them. Industrial problems are usually too complex for students, and, moreover, the answers are wanted too rapidly to make them subjects of a student's exercise; he will learn by failures; by the inexperienced the right road is only found at last after many tempting tracks leading nowhere have been vainly tried. The manufacturer who comes with a problem which cannot wait will be more sure to find a solution if he applies to men whose daily work it is to attempt such problems and who have the experience of the past to guide them. Moreover, the plant and equipment required is special; the industrial research laboratory must be fitted on the industrial scale. A rolling mill is not an adjunct required in every technical school where the principles of metallurgy are taught, and yet without a rolling mill (Figs. 2 and 3) the study of the light alloys at the National Physical Laboratory could not have been brought to the pitch it has been. The plant and equipment of an industrial research laboratory are provided for the purpose of applying science to industry. The requirements of students and the educational value of the apparatus need not be studied. There must, of course, be many specialised laboratories of industrial research; much more than the National Physical Laboratory is required. I will return to that point later. At present I merely wish to urge that university and technical college laboratories cannot fill all our needs.

And now let me come back to another illustration of the industrial research done at the laboratory closely

connected with our original work on wind pressure. The Advisory Committee for Aeronautics was first appointed in 1908 by Mr. Asquith, as Prime Minister. It owes its inception to Lord Haldane, and much of the experimental work which it has initiated, and which has had so marked an effect on the efficiency of British aircraft, has been carried out at the laboratory. At present there are five air channels (Fig. 4) in practically continuous use, and more are being erected. Some years ago I gave some account here of the work by which Bairstow and Busk, starting from Bryan's theory, had solved the problem of stability. It is impossible to tell at present of the progress made since that time, but when the day comes on which the tale can be told it will form a striking example of the work of a Laboratory of Industrial Research, and the results obtained for purposes of war will bear fruit in the rapid progress of civilian aircraft.

The Froude Tank is another department of our Laboratory of Industrial Research (Fig. 5). Built by Sir Alfred Yarrow in memory of Mr. William Froude, and for the service of the nation, he has had the privilege of seeing it repay its cost many times in the services rendered to naval warfare, while the pages of the Transactions of Naval Architects bear eloquent witness to the value of the work Mr. Baker has done for naval architecture generally. I could multiply instances. Perhaps I have said enough to justify the claim that, though with scanty means, we have been a Laboratory of Industrial Research of real value to the nation. In my former lecture I quoted a cynical remark made in regard to an advertisement for staff. It ran "The scale of pay is certainly not extravagant. It is, however, possible that the duties will be correspondingly light." The first sentence is still true; the staff have falsified the inference.

And now, turning to the future, let us consider what is to be the position of the institution as a Central Laboratory of Industrial Research.

In a lecture delivered in Birmingham rather more than a year ago, shortly after Lord Crewe had announced the formation of the Department of Scientific and Industrial Research, I referred to such laboratories, and I wrote:—

"There must be more than one; in many cases an industry can be best served by a laboratory near its principal centre. Large firms, again, may each prefer to have their own trade secrets—this must be so to some extent—and trade jealousies may interfere with full co-operation, but a private laboratory on a really sufficient scale is expensive; too often it becomes little more than what I have called a works laboratory for testing the products of the factory, and for the smaller firms, at least, the only way to secure the full advantage of scientific advance is by co-operation—co-operation in the laboratory, co-operation, with specialisation in production, in the works themselves."

It has been suggested that I wish to make the National Physical Laboratory not merely a national but the only bridge between science and industry. This is not the case; let me quote, in order that I may amplify them, the concluding words of the lecture:—

"Associations are to be formed representing various trades or industries; the representatives of these will discuss with representatives of the Advisory Committee, and other experts, questions needing scientific investigation and, when these are determined, the grant, supplemented in most cases by funds raised privately or contributed by the industry, is to be used to carry them out. Such work needs laboratories, and it is here, it seems to me, that the future of the National Physical Laboratory lies. The Lord President spoke in generous terms of the work of the laboratory in the past; its many friends who heard him were grateful for his cordial recognition of our labours, and he indicated a sphere of wider usefulness under less difficult conditions in the future. Let me picture to you what I trust that sphere may be.

"In many cases, no doubt, the researches contemplated must go on in special laboratories arranged and equipped for the purpose—laboratories closely connected with the industry it is desired to help, situated at the great manufacturing centres; but there are many other researches of wide interest and great importance for which a central laboratory is the proper house, a laboratory fitted and equipped in an ample manner, with a trained and competent staff animated, like those, my colleagues, who have built up the National Physical Laboratory, with a love for science and yet withal with a keen appreciation of the practical side of the question discussed and a real desire to help our country by the application of science to industry.

"The body controlling industrial science research must have access to a laboratory in which may be studied the many problems which do not require for their elucidation appliances of the more specialised "works" character, or opportunities only to be found in particular localities: where a staff is available, able and experienced, ready to attack under the advice of men skilled in industry, the technical difficulties met in applying new discoveries on a manufacturing scale or to develop ideas which promise future success.

"Such a *rôle* the National Physical Laboratory should be prepared to play, such is the future which I trust may be in store for it."

This work has already been begun. The various trades associations have been formed, or are being formed, for the promotion of research on matters of interest to the members of the trade.

The principal objects of an association, as they would be laid down in the Memorandum of Association, may be briefly summarised thus:—

(*a*) To promote research in connection with the manufacture and use of . . . . . by maintaining or subsidising existing laboratories and workshops, or, if necessary, establishing and equipping laboratories and workshops.

(*b*) To retain or employ skilled professional or technical advisers in connection with the objects of the association.

(*c*) To encourage the discovery of, and investigate the merits of, improvements which may seem capable of being utilised for the purpose of the respective industry, and to take out patents or licences relating to such inventions or improvements and to perfect and develop them.

(*d*) To support or to establish libraries, collections, or museums necessary for the promotion of the industries concerned.

(*e*) To publish or to assist in publishing any literature, statistics, or information relating to the subject of . . . that may be of value to members of the association.

(*f*) To promote in any way desirable the education of those engaged or likely to be engaged in the industries concerned.

FIG. 4. THE 7-FT. WIND CHANNEL.

(*g*) To co-operate with other associations or bodies having objects bearing on the work of the association.

(*h*) To apply to the Government for, and to accept, grants of money and other assistance for the purpose of the objects of the association and to discuss and negotiate with the Department of Scientific and Industrial Research and other Government department's schemes of research and other matters within the objects of the association.

Each such association will probably require its own laboratory situated, for preference, at the centre of the trade concerned. This will deal with the special problems of the trade, problems which need intimate association with works conditions for their solution and for which the close supervision of men in works is important.

But there are numerous industrial problems which can best be dealt with in a central laboratory; let me give some instances of what I mean. Such, for example, are:

(1) Investigations into methods of standardisation or of measurement generally.

(2) Investigations into the physical and mechanical properties of materials used in many trades.

(3) Investigations useful to a trade which has no fixed centre, but is widespread over the country.

Or, again, (4) a central laboratory will be of service as a means whereby information as to large questions of general interest, investigated either at the central laboratory itself or at the local special laboratories, may be circulated and time saved by placing at the disposal of any special laboratory requiring them the results obtained elsewhere.

Taking these heads more in detail. I will postpone the consideration of No. 1—standardisation problems—to my next lecture. It is sufficient to remark here that the work already done in this direction has been very great, and to point out that unification of standards used in various trades is highly desirable and can only be secured by the existence of a central standardising institution working in close co-operation with local institutions.

Turning, then, to (2)—investigations into the properties of materials used in many trades, the work done on light alloys affords a good example of this; work for which the British Aluminium Company have recently shown their appreciation by sending a generous donation of 500*l.* to the funds of the laboratory. They write as follows:—

"The Board of Directors of the British Aluminium Company, being desirous of showing their appreciation of the research work that has been, and is being, carried on at the National Physical Laboratory, in connection with light aluminium alloys, and with a view to assisting towards further work awaiting accomplishment in the same direction, have unanimously voted a donation of 500*l.* to the funds of the laboratory.

"A cheque for that amount I have pleasure in enclosing.

"My directors do not wish to make any special conditions attaching to this donation, other than that they desire it to be applied, as and when opportunity offers, towards research in connection with the development of light aluminium alloys, leaving it to your discretion to determine the exact application of the grant, whether as to the provision of instruments and plant, or technical supervision, or in any other direction which may commend itself to you.

I take this opportunity of expressing, on behalf of my board and myself, our satisfaction with the results which have so far been achieved, and our firm conviction that, given time and suitable conditions, still further and material advances will follow in due time, from which material benefit should accrue to industry."

Or, again, the following are a few of the problems which it has been recently stated need solution to satisfy the needs of one important industry :—

(1) An investigation into the physical properties of alloy steels.

(2) An investigation into the conditions affecting the flow of liquid fuel through an orifice with reference to :

(*a*) Proportions of orifice ;
(*b*) Temperature of fuel and air ;
(*c*) Viscosity of fuel.

(3) An investigation of the stress distribution in irregularly-shaped members—crankshafts and the like.

(4) An investigation into the wear of bearings.

(5) Investigations into the material suitable for valves, cylinders, and other parts of internal-combustion engines.

(6) The efficiency of radiators for such engines.

(7) An investigation into the cause of the lubricating properties of oils with a view of framing a specification for such oils.

Thermal conductivity.
Electrical conductivity.
Thermal expansion.
After expansion and contraction.
Softening point (with and without load).
Thermal endurance.
Crystallography.
Texture (grain-size).
Porosity.
Density.
Permeability to gases.
Penetration by molten metals.
Mechanical strength.
Hardness.
Resistance to abrasion.
Resistance to chemical action.

(*b*) Standardisation of tests and formulation of specifications in each class of material.

(*c*) A study of the properties of all refractories and metallic oxides associated with them, up to the highest attainable temperatures, with special reference to their physico-chemical transformations.

(*d*) Development of micro-technology as applied to refractories.

kind. Brick and stone, wood and iron, have been used for long, and their properties when employed for building construction are generally well known. This is less true of other more modern materials—ferro-concrete, for example. There are rules—based no doubt on the best experience available—for estimating the strength of beams, columns and floors, but there is much scope for inquiry. Accordingly, at the instance of Sir John Cowan, of the firm of Messrs. Redpath, Brown and Co., who is bearing the expense, apparatus is being built to test columns up to 15 ft. or 20 ft. in length and floors of considerable size. War conditions again are interfering, but the work is progressing slowly and must be done. There are other materials besides ferro-concrete urgently calling for examination. Nor is the strength of the materials the only factor to be considered. Materials transmit heat in very varying amounts and the comfort of a house, to say nothing of the cost of living in it, will depend on whether it is possible easily to keep it warm in winter, cool in summer. Recently we were asked to compare the heat losses from two enclosures exactly alike in all respects, except that the one was roofed with corrugated iron, the other with some preparation of asbestos. It was found that the latter cooled 20 per cent. faster than the former ; the loss of heat depends,

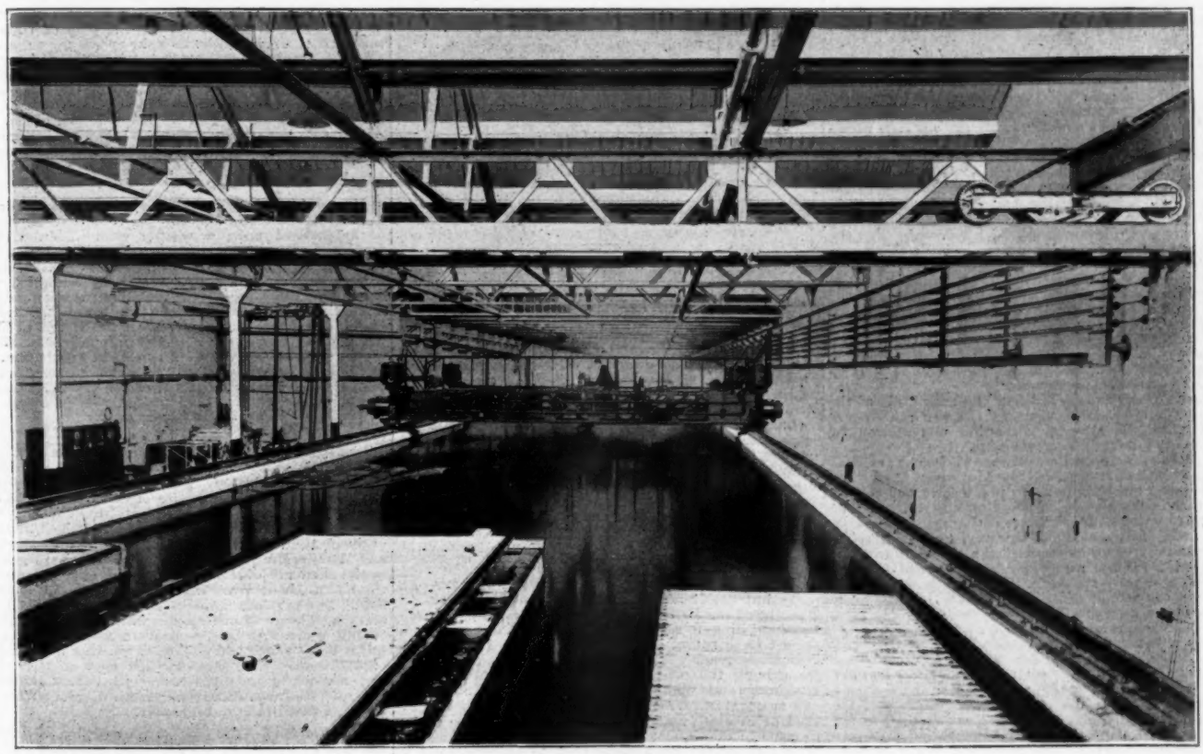


FIG. 5. THE WILLIAM FROUDE MEMORIAL SHIP MODEL TANK.

It is obvious that the results of all these investigations, while of special importance to the automobile industry, are of great interest to others. Any of them could go on in a properly equipped laboratory, while it is clear that to carry out many a very complete physical and, in some cases, chemical, equipment is needed.

And that leads to another very important point. A special laboratory, if it is to be really of use, must be complete. Many of the investigations just indicated involve thermal and electrical measurements of high accuracy. Elaborate apparatus is involved and a skilled staff to use it. These conditions can only be satisfied if the laboratory possesses a large and varied staff, capable of advising on each special point as it arises, and the necessary outfit of delicate and expensive apparatus. In many instances the difficulty lies in the development of the method of measurement and the calibration and standardisation of the apparatus employed rather than in the actual experiments.

Or, to take another instance. There have been some conferences lately with regard to research in refractories, and it was clear that there is much work to be done and ample opportunity for the development of research in special laboratories in close contact with the industry, whether at Sheffield, Middlesbrough, or South Wales, for steel-making and other metallurgical processes, or in the Potteries for the china and earthenware trades. It was clear, too, that there was much work which could best be done at a central institution such as the National Physical Laboratory. Such work, for example, would embrace :—

(*a*) The investigation of the following physical, physico-chemical, and mechanical properties of refractories under service conditions :—

(*e*) A special study of the rarer refractories.

As instances of (3)—Investigations useful to a trade which has no fixed centre—I may give the following :—

1. A research has been in progress for some time at the laboratory into the heating of buried cables carrying electric currents. In connection with the Wiring Rules Committee of the Institution of Electrical Engineers much has been done to determine the temperature to which the cables used in house wiring are raised in various circumstances, and to fix the safer currents to be used in each case. Our knowledge of the temperature reached in cables when buried in the ground is very scanty and somewhat conflicting ; much depends on the nature of the covering used to protect them, and possibly something on the nature of the soil. Cables laid in ducts, again, differ from those protected merely by the ordinary forms of lead or other covering, and yet the life of the insulation depends in great measure on the temperature reached when the current is flowing and thus regulates the carrying capacity of the cable. Thanks to the co-operation of supply authorities in many parts of the country much valuable information has been collected, and, though the research at the laboratory proceeds but slowly, results of great importance are being obtained. Such a research needs large appliances, and currents up to 8,000 amperes or 10,000 amperes will be employed. It needs also the resources of a fully-equipped physical laboratory in order to measure accurately the temperature differences due to varying conditions ; when complete it will be of value to all supply companies. This is true of many other electrical tests and experiments ; the results are of wide application ; it is desirable that they should be widely published.

The building trade offers another example of this in part, on the conductivity of the material, in part on the emissivity of its surface, and the superior emissivity of the asbestos sheet more than made up for its inferior conductivity. In this connection it is clear there is much to be done, and for such work a central laboratory, with proper equipment, is the most suitable place. Arrangements are in progress by which it is hoped many of these questions will be thoroughly investigated.

Little need be said as to the fourth section of the work suggested for a National Industrial Research Laboratory.

The importance of the collection and dissemination of information on matters connecting industry and science is clear. At a central laboratory much of the information will be to hand ; the accumulated experience of the staff, their knowledge of the work done in the sectional laboratories, their appreciation of the bearing on industry of inquiries in the region of pure science, are all valuable assets and a proper organisation only is needed—by means of a bulletin or in some such way—to circulate their information where it is most wanted.

There is ample room for a central laboratory without trenching in the least on the spheres of the local sectional institutions. If the Department of Scientific and Industrial Research is to carry out effectively the work it contemplates such a laboratory is essential, and my hope is that the National Physical Laboratory may develop into such an institution in close connection, through the department, with local laboratories throughout the country.

One word in conclusion. The workman is worthy of his hire. In the past the scale of pay has certainly not been extravagant, and there is no call for extravagance in the future, but the remuneration offered must be

sufficient and the conditions of work fair. Much has been written lately as to the inadequate remuneration of scientific workers, whether teachers or the expert staff of laboratories and factories, and it is realised, I trust, that the time has come to change this for men and for women alike. To-day there is a great demand for scientific workers, and while, as in other walks of life, commercial life must offer greater prizes than Government service, it is essential, if the necessary work is to be done and the workers retained, that the emoluments of technical posts under Government, and the conditions attached, should be as good as those of the regular administrative staff of the civil service. This must apply not merely to the heads of the various institutions, but to the rank and file on whose labours success depends. This point I need not labour here, but in pressing it I feel confident I shall have the support of all who appreciate the importance of science to the nation.

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting held on February 22, at the Imperial College of Science, Professor C. H. Lees, F.R.S., president, in the chair, a paper, entitled "*A Note on the Use of Approximate Methods in Obtaining Constructional Data for Telescope Objectives*," was read by Mr. T. Smith.

The paper discusses the reason why satisfactory telescope objectives are obtained by neglecting thicknesses and solving for freedom from first order aberrations. It is shown that the introduction of thicknesses into such an objective, without any alteration in the curvatures of the surfaces, yields a lens corrected for aberration for a zone which is a constant fraction of the full aperture obtainable. For objectives of the usual type this zone is very approximately the one that would be selected for correction to obtain the most favourable balance between first and second order aberrations. It follows that objectives calculated from first order formulæ in which thicknesses are neglected do not require trigonometrical verification or correction unless the conditions are very abnormal.

Discussion.—Professor J. W. Nicholson said that the author had brought out an important point in this paper. There was an idea prevalent in many quarters that the thin lens was simply an abstraction of no practical importance, but apparently this was by no means the case. He had been familiar in a general way with this compensation of first and second order aberrations, but had never seen it mentioned in any publication. Were there any convenient circumstances in which both coma and spherical aberration were simultaneously compensated for the same aperture?

Professor C. H. Lees asked how the magnitude of the residual aberration or the shape of the aberration curve altered when the zone of correction was altered by changing the index of the crown glass.

The author, in reply to Professor Nicholson, said he had not worked out numerical cases for coma, though the formulæ were quite simple. In practice, it was usually found that in the absence of spherical aberration if the coma was approximately corrected the result was satisfactory. He had no doubt, however, that with triple objectives both coma and spherical aberration could be compensated for the same aperture. In reply to the president, generally speaking, with very low indices of the crown the second order aberration was large, while with indices nearer the flint it was smaller. The ratio of extreme cases might be about 5 to 1.

A paper, entitled "*A Suggestion as to the Origin of Spectral Series*," was read by Dr. H. Stanley Allen.

The note gives a development of an idea put forward in an earlier paper, describing an atomic model with a magnetic core. It is assumed that the principle of the constancy of angular momentum may be applied to the total angular momentum of the electron, and a certain part of the core bearing a special relation to the electron. On the line of Bohr's theory this leads to an expression for the oscillation frequency, which is similar to Rydberg's formula, and contains a constant which is the same for all elements. The "phase" μ of a "sequence" is regarded as proportional to the angular momentum of a definite portion of the core. In observed series the phases of the two sequences are not equal to one another—consequently, whatever interpretation be given to the phase, the two types of state concerned must be in some way different from one another. When the magnetic field of the core is taken into account, a formula is obtained which is identical with that of Ritz. An explanation of the series of enhanced lines in spark spectra is also suggested.

Discussion.—Professor J. W. Nicholson thought the fundamental assumption in the paper seemed a natural one. Bohr's theory, in the case of hydrogen, assumed the angular momentum to be proportional to the integers in Balmer's series. In the case of more complex atoms we were compelled to assume that $\tau + \mu$ was the quantity to which the angular momentum was proportional. To consider this extra angular momentum to be attached to the nucleus was, of course, another assumption. It was equivalent to attaching a physical significance to tubes of force, which Sir J. J. Thomson had always tried to do. An interesting feature of the theory was that it gave the series of enhanced lines of spark spectra, and the physical interpretation of $k = 2$, viz., that these were due to atoms with another electron torn off, seemed very feasible. As was pointed out in the paper, any theory involving stationary states must allow for different types of stationary state—i.e., different values of μ_1 and μ_2. The considerations by which Rutherford deduced the smallness of the nucleus were founded on the mathematical work of Darwin, and, on the assumption that the nucleus was wholly electrical were faultless. The fact that the nucleus might be magnetic was pointed out by Hicks, who showed that the scattering of a particles by atoms might be accounted for by magnetons rather than electrons.

Professor G. W. O. Howe asked what was the reason for applying the word "phase" to μ. To an electrician phase had a very different meaning. What was the significance of the initial equations with which the paper started out?

Professor Lees asked if the atom suggested by Dr. Allen would give the same scattering effects as had been experimentally found?

The author, in reply, said the term "phase" was due to Rydberg, and was introduced before the quantum theory was evolved. He did not know why the term had been selected. He was afraid he could not answer Professor Howe's second question. These equations were fundamental to the quantum theory, and to understand them fully one would have to know all about quanta and the constitution of matter. With regard to the scattering of α particles, he thought it was possible to explain this as done by Hicks, if we took into account the magnetic action of the core. Of course, the electric action was also there and had to be taken into account as well. The results of experiments on scattering did not preclude the introduction of magnetic forces.

2,000-KW. TO 2,400-KW., 50-CYCLE MOTOR CONVERTERS.—The Sydney Municipal Council, Australia, will shortly put down a 2,000-kw., 50-cycle motor converter. The Manchester Corporation installed a few years ago a 2,200-kw., 50-cycle motor converter. These machines have been built by Messrs. Bruce, Peebles and Co., Limited, Edinburgh, who have received an order for a 2,000-kw. motor converter for the Johannesburg Municipality, and an order from the Manchester Corporation for a second machine, of 2,400 kw. These machines will be the largest 50-cycle converting units manufactured in Great Britain. The 2,000-kw. motor converter is the fourth 50-cycle machine supplied to the Municipality of Sydney, the other three machines having a capacity of 1,000 kw. each.

A "TORPEDO-PROOF" SHIP.—The Washington correspondent of *The Times* states that the Naval Board under Admiral Winterhalter has left Washington for Norfolk, Virginia, to conduct tests of the "unsinkable torpedo-proof" ship Lucia, fitted out by the Committee of Inventions of the Naval Consulting Board, of which Mr. Edison is president and Mr. W. L. Saunders executive chairman. It is sought to establish whether, by sacrificing 14 per cent. cargo-carrying capacity and from 2 knots to 3 knots speed, a vessel can be made virtually unsinkable. The Naval Board will inspect the ship, load her and send her across the Atlantic without convoy, but with an armed guard to prevent a submarine from boarding her and destroying her by dynamite or fire. The Lucia is equipped with honeycomb, airtight boxes, which the Committee of Inventions asserts will keep her afloat even after a direct hit from a torpedo, such as would sink an ordinary ship in a few minutes.

PROPOSED IMPERIAL BANK OF INDUSTRY.—An important report has been issued by the Committee on Banking of the British Empire Producers' Organisation recommending a scheme the main features of which are set forth below. The general motive of the scheme is to afford readier financial support on sound principles throughout the United Kingdom and the Overseas Dominions and Colonies for producers and manufacturers, and amongst other results it is intended that there shall thus be in any event no opening for German financial intrigue in obtaining control of any group of industry. It is claimed for the scheme that on the one hand it involves no departure from methods which have been successfully demonstrated on a national scale, and on the other hand it conflicts in no way with the ordinary business of joint stock banks, but is, on the contrary, calculated to increase their turnover. The available capital is to be provided in the shape of debentures and deposits with State guarantee. Further capital will also be accumulated by the funding of profits, as apart from a small bonus to debenture holders and depositors all surplus will remain in the bank. Provision is made for government by boards of trustees, on which both employers and employed would be represented. Suggestion is made as to the guarantee capital by the United Kingdom, the Dominions and Colonies making a total of 50,000,000*l.*, to be enlarged as demand shall arise. The objects are: To strengthen and to extend producing and manufacturing industries already established in the Empire; to assist in the foundation and development of new industries therein; to assist by credit facilities in the sale of their products; to assist them in procuring materials, machinery, and facilities from other parts of the Empire; to assist in the acquisition within the Empire by its citizens of control and utilisation of its own products; the foregoing to apply only to companies, firms and individuals of British origin and whose registration is within the British Empire. The methods enumerated are: Making advances by way of cash credits against such security or guarantee as the trustees shall deem sufficient; accepting drafts made against shipments or deliveries of industrial products or of materials; buying and selling bills of exchange against collateral security; issuing letters of credit; discounting trade bills; purchase of secured time payment accounts or by advances upon the same; to assist and to co-operate with other financial institutions in underwriting the share and debenture issues of present or future industrial undertakings; to collect and collate information likely to be useful to its customers.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Every effort is being made to increase the output of steel, and steelmakers are fully alive to the urgent necessity of keeping the supply at least with the demand, which still continues on an abnormal scale. The demand for steel for shell bars and for shipbuilding shapes and sections keeps the mills fully employed. With the ever-increasing production it is confidently expected that before very long a certain proportion of the output may be available for export if, as is being quietly suggested in certain quarters, the shipyards are now receiving a requisite delivery of material. A considerable amount of repair work is constantly in progress, a contingency not to be avoided under the exceptional circumstances at present ruling.

Malleable Iron Trade.—Malleable iron makers were never busier, and now every ton of their output is consumed, either directly or indirectly, on war account, and nothing remains for ordinary mercantile business. Even with this much difficulty is experienced in maintaining deliveries at the required level. Large-sized bars of cable quality are greatly in demand, apparently for shipbuilding purposes, while the smaller sizes—bolt quality for the rivet works—are not far behind.

Scotch Pig-Iron Trade.—No change in the conditions of activity at present ruling in the pig-iron trade has taken place or is likely to take place for some considerable time ahead, the demand for the entire production being as brisk as could possibly be conceived. Everything is rapidly swallowed up by the steel works engaged on Government contracts. Hematite is still scarce, and so are certain brands of foundry iron. All things considered, the marvel is that production has been so well maintained, and it reflects the greatest credit on those who have endeavoured so strenuously to keep matters moving on so satisfactory a footing.

Honour to Clyde Shipowner.—Much satisfaction is felt in the city that His Majesty has conferred the honour of knighthood upon a worthy citizen, Mr. William Hannay Raeburn, senior partner of the firm of Raeburn and Verel, shipowners, Glasgow. Sir William has taken a very active interest in everything connected with shipping, more especially as regards legislation, and for a number of years he has been a member of the Advisory Committee formed to confer with the Board of Trade in its supervision of the Merchant Shipping Acts. While his services have always been in great requisition, one of the most important positions which he has filled has been that of deputy chairman of the Clyde Navigation Trust.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Coking Qualities of Coal.—Interesting facts with regard to the coking qualities of South Yorkshire coal, and the importance of chemical investigation, were given by Professor W. G. Fearnside, of the University of Sheffield, in an address to the Society of Metallurgists and Metallurgical Chemists. He pointed out the change in the character of the Barnsley seam as it passed from the north, about Wakefield, to the south, about Mansfield. In the north it made good coke, and would also carry a mixture of other coals which were less good as coking coals. About Sheffield it would make coke, but it was "touch and go" as to whether it made good coke or not. The boundary line between the coking and non-coking qualities came just about the Great Central Railway, between Sheffield and Worksop. South of that line it did not coke.

Iron and Steel.—The enormous expansion of Sheffield works is evidenced by the fact that in certain branches of production the supply has for some time past well exceeded the requirements of the market. In certain qualities of steel stocks have accumulated, and, as contracts are not being renewed, manufacture is becoming more and more limited. This has resulted in the discharge of a considerable number of munition workers, chiefly women. In one establishment alone 800 received notice on Saturday last. The steel output of the country has enormously increased during the past twelve months, and imposes a severe strain on blast-furnace plants. The big part which electric steel is now playing in manufacture, and the still greater part which it is bound to play after the war, is becoming recognised by the authorities, who have recently adopted a more encouraging attitude towards the electric-furnace industry. Early last year an Order was issued by the Ministry of Munitions prohibiting any further installations except by their permit. This permission was frequently withheld, thus discouraging many firms anxious to progress with the times. The more sympathetic frame of mind which the Ministry has adopted will enable the British steel trade to make up arrears. In the lighter industries considerable pressure exists. Supplies of tools are urgently required, and all makers are well booked ahead. Every class of garden implement is in demand and manufacturers state that the demand for this class of tool is fully three times as great as before the war. Similar reports are to hand with regard to field tools, and there is little possibilty of all orders being executed ere the season's demand is over.

South Yorkshire Coal Trade.—Business in all qualities of steam fuel is as heavy as ever, the inland works requiring full supplies, while the railway companies, blast and converter furnaces are taking well over their contract tonnage. Nuts and slacks are scarce, supplies of the former being very difficult to obtain. Shipping business is brisk, chiefly to France and Italy. Heavy

deliveries are being made on contract account of gas fuels. Blast-furnace cokes are in strong demand, prices holding at maximum rates. There is but little change in the house-coal market. The Coal Controller still calls for a substantial tonnage for the metropolitan market, though the pressure is hardly as great as a month ago. Short supplies are still the rule in many districts. Pits are working full time wherever transport facilities will permit. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.*, per ton at the pit.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—No difficulty is experienced in obtaining March allocations of Cleveland foundry iron for home consumption, but although makers have plenty of iron for disposal, obstacle to distribution is serious, though it is stated that steps are being taken to facilitate repair of disabled rolling-stock. Home forward demand for forge iron continues heavy, but few contracts are being made, producers still being disinclined to commit themselves ahead. Export transactions in Cleveland pig-iron are on only a limited scale, but better supply of ships are expected this month, and March shipments are likely to be larger than those of February. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all stand at 95*s.*, and No. 1 is 99*s.*; whilst for shipment to France and Italy these qualities are quoted 114*s.* and 119*s.* respectively.

Hematite Iron.—Conditions continue stringent in the East Coast hematite branch, but there are prospects of some relief in the near future by enlargement of production. Meanwhile essential needs of home consumers are being met, and a little iron is available for export. Mixed Nos. are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for shipment to the Allies.

Foreign Ore.—Deliveries of foreign ore are coming forward better, and a fair volume of new business passing on the basis of the advanced price. It is understood that the 2*s.* 6*d.* advance is payable on all shipments of hematite ores as from January 25 last to June 30.

Coke.—The coke market continues fairly active, and strong, plentiful supply having no apparent detrimental influence on quotations. Demand keeps good. Average blast-furnace kind is 33*s.* at the ovens, and low phosphorus quality 35*s.* 6*d.* at the ovens. For shipment, foundry coke is 42*s.* 6*d.* f.o.b. to the Allies, and 45*s.* f.o.b. to neutrals.

Manufactured Iron and Steel.—Very little new is ascertainable concerning the manufactured iron and steel industries. With producers still very fully engaged endeavouring to cope with the huge Government needs, and the heavy demands of the shipyards, few facilities were afforded for the transaction of business in other directions. Output of material for the shipyards is reported on an enormous scale. Prices, all round are stiff. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 15*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough during February were officially returned at 37,518 tons, of which 26,491 tons were pig-iron, 944 tons manufactured iron, and 10,083 tons steel. For the previous month the clearances totalled 51,718 tons, composed of 31,022 tons of pig-iron, 1,512 tons of manufactured iron, and 19,184 tons of steel.

Industrial Developments on Tees-side.—Important extensions are being arranged by Messrs. Smiths Dock Company, Limited. The Tees Furnace Company, Limited, are also about to make great extensions at their Lackenby Ironworks, Middlesbrough. At a meeting of the Tees Conservancy Commissioners this week, Mr. J. H. Amos, general manager, reported that on behalf of the Tees Commissioners he had attended meetings in London with the managing trustee of the Kirkleatham estate, the chairman of Smiths Dock Company, Limited, and the managing director of the Tees Furnace Company, Limited, Lackenby Ironworks, in regard to proposed sales of land, and as a result it was mutually agreed that the terms and conditions offered by H.M. Commissioner of Woods and Forest, and the Tees Commissioners, be accepted by all parties concerned. The sales would, therefore, be carried out on the following lines:—(1) 74 acres of Tees tidal foreshore, and also 7 acres of land (the latter the property of the Kirkleatham estate), making in all about 81 acres, to Smiths Dock Company, Limited. (2) The adjoining tidal foreshore of about 76 acres to the Tees Furnace Company, Limited. Mr. Amos intimated that this disposed of the whole of the land on the Tees foreshore (Yorkshire side) which was in the possession of the Tees Conservancy Commissioners.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Pits are this week working better than was the case at the end of last week, and comparatively few collieries were reported idle to-day. The chief subject of discussion this week has been that of the Order of the Coal Controller directing exporters to remit to the collieries the customary one-third of the 5 per cent. brokerage. Hitherto the trade has been very submissive to the authorities in London, into whose hands the conduct of the production and distribution of coal has been reposed by Defence of the Realm Regulations; often in cases where the policy and methods pursued by those authorities have been considered clearly opposed to public interest traders have refrained from hostile action from a desire not to hamper the Government in the prosecution of the war. It is felt, however, that the latest Order of the Controller is of so arbitrary a character and so subversive of all that is regular and sound in the conduct of business, that it cannot be allowed to enter even a system of State controlled industry without something more effective in the way of disapproval than the adoption of condemnatory resolutions. The exporters of Swansea have taken a logical, and a very drastic course, by their decision to refuse to hand over the collected brokerage, but it is not likely that other exporting ports of the country will adopt so extreme a measure. Under pressure of an overwhelming body of opinion, a special meeting of the Cardiff Chamber of Commerce was held, when the whole position was explained in detail. The upshot of the meeting, which was largely attended, was a decision to try to seek an interview with the Prime Minister on the subject, and failing this, that steps be taken with the view of getting the question raised in Parliament.

Newport.—The position in the Monmouthshire district is not satisfactory, and it is now the practice of some of the collieries to restrict their production to about four days a week. Considerable interest is now taken in the new allocation scheme, and it is anticipated that some of the collieries in the Eastern and Western Valleys will benefit from the contemplated redistribution of orders. The facilities for inland transport are capable of improvement, but on the whole pits producing coal for household and manufacturing consumption are working fairly regularly.

The Allocation of Orders.—Although the Board of Trade has not yet issued the new allocation scheme in the form of an Order, the main details of that scheme have now been communicated to the collieries. The scheme, which aims at the equalisation of trade as far as practicable, was again considered to-day, and will apparently be put into operation immediately the formal sanction of the authorities is obtained.

THE GERMAN BABCOCK AND WILCOX BOILER COMPANY.—This company now has a share capital of 5,000,000 marks, and reserves amounting to 1,400,000 marks. The company has works at Oberhausen and Gleiwitz. The more important of their boiler patents expire in 1921 and 1922. The company paid 12½ per cent. for the year 1916–17, against 10 per cent. for the four preceding years. The number of hands employed is about 1,000.

PERSONAL.—A new company has been registered under the title of the E. W. Harvey Gas Furnace Company, Limited, the proprietors of which are the managers and staff of the Siemens regenerative gas furnace business carried on at 10, Queen Anne's Gate, Westminster, in the name of "Frederick Siemens, successor to Sir William Siemens." The business was originally established in London by Sir William Siemens in 1856 with a British staff, and the new company, through its managing director, Mr. Ernest Wm. Harvey, having acquired the goodwill and assets of Frederick Siemens, is therefore now an all-British concern. The new proprietors have been for many years the sole responsible managers at Westminster of the Siemens furnace business in Great Britain, France, Belgium, Spain, Italy, Australia, India, Japan and the Transvaal.—Messrs. John Birch and Co., Limited, 2, London Wall Buildings, E.C. 2, inform us that they have recently secured the export rights in connection with Railless, Limited, and add that tramway managers and all who are responsible for or concerned with public transport (or public conveyance of passengers and goods on roads and streets) will be interested to learn that a new company has recently been formed to take over the patents and goodwill of the R.E.T. Construction Company. Its name, "Railless, Limited," sufficiently indicates its objects, and it only remains to state that it will work the well-known R.E.T. system which has been operating successfully for several years in various towns, including Leeds and Rotherham at home, Boksburg and Bloemfontein in South Africa, and Shanghai in China. Obviously, at the present moment the work of the company must be to a great extent preparatory, but much preliminary work can be done now and the way paved for meeting the widespread demands for increased facilities of travel which will follow the conclusion of peace.—Messrs. Malcolm and Allen, Limited, 499, Eglinton-street, Glasgow, inform us that they have secured the sole agency for Scotland from Messrs. Automatic and Electric Furnaces, Limited, for the sale of the Wild-Barfield electric furnaces and steel hardening equipment. They are installing a demonstration plant at the above address, and would be very pleased to show this in operation to any of our Scotch readers who are interested in the modern heat-treatment of carbon steel.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, March 8, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W. Agenda:—(1) "The Asymmetrical Distribution of Corpuscular Radiation Produced by X-Rays," by Mr. R. A. Owen, B.A., M.Sc. (2) "On 'Air Standard' Internal Combustion Engine Cycles and their Efficiencies."

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Saturday, March 9, at 3 p.m., at the Danum Hotel, Doncaster, when the following paper will be read:—"Some Useful Instruments for Colliery Power Plants," by Mr. H. W. Ravenshaw. The following paper will be open for discussion:—"Face Conveyors," by Mr. R. C. Jenkins.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, March 9, at 6.30 p.m., at the Institute, Wolverhampton Street, Dudley. A paper, on "Steel Ingots," will be read by Mr. J. N. Kilby, of Sheffield.

THE SOCIETY OF ENGINEERS.—Monday, March 11, at 5.30 p.m., in the apartments of the Geological Society, Burlington House, Piccadilly, W. A paper, entitled "Concrete Mixtures for Ferro-Concrete Work," will be read by Mr. T. J. Gueritte, M.Soc.Ing.Civ. (France), M.S.E.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 12, at 5.30 p.m. By permission of the Council, an exhibition of cinematograph films, illustrating water power works in Canada, will be given by Professor J. G. McLellan, acting on behalf of the Canadian Government.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Tuesday, March 12, at 7 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate Road, Newcastle-on-Tyne. The following paper will be read and discussed:—"Ferro-Concrete Ships," by Mr. T. J. Gueritte, Ing.E.C.P., M.Soc.Ing.Civ. (France), Councillor of the French Board of Trade.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, March 12, at 7 p.m., at the Princes Street Station Hotel, Edinburgh. Paper:—"Electrical Signalling and Control on Railways," by Mr. C. M. Jacobs. Subject to be introduced by Mr. W. Wood, Member.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, March 13, at 8 p.m., at St. Bride's Institute, Bride Lane, Fleet Street, E.C. A paper will be read by Mr. A. H. Barker, Wh. Sc., B.A., B.Sc., on "The Superintendence of an Engineering Plant at a Large Hotel." Mr. W. H. Patchell, M.Inst.C.E., M.I.Mech.E., in the chair.

THE ROYAL SOCIETY OF ARTS.—Wednesday, March 13, at 4.30 p.m. Ordinary meeting.—"Ypres and other Flemish Cities before and since the War," by Monsieur Paul Lambotte, Directeur des Beaux Arts au Ministère des Sciences et des Arts de Belgique. (In English.) His Grace the Archbishop of Canterbury will preside. The paper will be illustrated by numerous lantern slides from unpublished official photographs. Thursday, March 14, at 4.30 p.m. Indian Section.—"English Commerce with India, 1608–1658," by Mr. William Foster, C.I.E.

THE NOTTINGHAM SOCIETY OF ENGINEERS.—Wednesday, March 13, at 7.30 p.m., at the Large Theatre, University College, Nottingham, when a lecture will be given on "Metrology—the Science of Exact Measurement" (illustrated by experiments and exhibits), by Dr. P. E. Shaw, B.A., D.Sc., University College, Nottingham. Mr. G. J. Ward, M.I. and S.I., will occupy the chair.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, March 13, at 8 p.m., at the Royal Society of Arts, John Street, Adelphi, W.C. Mr. F. L. Martineau will read a paper, entitled "Nomography, with a few references to its use in Engine Design."

THE INSTITUTE OF METALS.—Wednesday, March 13, at 8 p.m., and Thursday, March 14, at 4 p.m. and 8 p.m., in the Rooms of the Chemical Society, Burlington House, Piccadilly, London. The following communications are expected to be submitted in the order given:—(1) Paper—"The Relationship between Hardness and Constitution in the Copper Rich Aluminium-Copper Alloys," by Mr. J. Neill Greenwood, M.Sc., Manchester. (2) Paper—"Aluminium-Bronze Die Casting," by Mr. H. Whitaker, M.Sc., Manchester, and Mr. H. Rix, Manchester. (3) Note—"On Grain Size," by Mr. G. H. Gulliver, D.Sc., London. (4) Note—"Lead-Tin-Antimony Alloys," by Mr. Owen Wm. Ellis, M.Sc., London. (5) Paper—"An Investigation on Unsound Castings of Admiralty Bronze (88 : 10 : 2): Its Cause and the Remedy," by Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M., London, and Miss C. F. Elam, London.

THE OPTICAL SOCIETY.—Thursday, March 14, at 8 p.m., at the Imperial College of Science and Technology, South Kensington. Papers:—"Reflecting Prisms," by Naval Instructor T. Y. Baker, R.N. "The Detection of 'Ghosts' in Prisms," by Mr. T. Smith, B.A.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 15, at 5.30 p.m. A discourse will be delivered by the Right Rev. W. Boyd-Carpenter, K.C.V.O. The subject will be "The Romantic Movement." Afternoon lectures next week at 3 p.m. Tuesday, March 12. Dr. Leonard Hill, M.B., F.R.S., on "The Stifling of Children's Health" (Lecture I). Thursday, March 14. Sir Alexander Mackenzie, Mus.Doc., D.C.L., LL.D., M.R.I., on "War Music: Past and Present" (Lecture II). Saturday, March 16. Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., on "Problems in Atomic Structure" (Lecture V).

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 15, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. Two papers on "Employment of Women in Munition Factories," by Miss O. E. Monkhouse, M.B.E., of London, and Mr. Ben. H. Morgan, of London.

TIN AND TUNGSTEN RESEARCH BOARD.—As the outcome of a conference held on November 7, 1917, at which there were present representatives of the Committee of the Privy Council for Scientific and Industrial Research, of the Department for the Development of Mineral Resources, and many of the land and mine-owners of Cornwall, a fund for research has been raised, and a Research Board has been appointed by the Committee of the Privy Council, consisting of: Sir Lionel Phillips, Bart. (chairman); Mr. John G. Gilbert, Cornish Chamber of Mines; Sir Frank Heath, K.C.B., Department of Scientific and Industrial Research; Sir Thomas Kirke Rose, chairman of the Research Committee of the Board; Mr. Edgar Taylor, Institution of Mining and Metallurgy; Mr. R. Arthur Thomas, Cornish Chamber of Mines; Sir Richard Threlfall, K.B.E., F.R.S., Advisory Council for Scientific and Industrial Research; with Mr. A. Richardson as secretary (15, Great George-street, Westminster, S.W. 1). The board, after consultation with their Research Committee, have authorised extended lines of research with a view to increasing the recovery of metal in the treatment of ores.

PLATE FULCRUM TRACK WEIGHBRIDGE.

CONSTRUCTED BY MESSRS. E. AND T. FAIRBANKS AND CO., ST. JOHNSBURY, VT., U.S.A.

(*For Description, see Page* 251.)

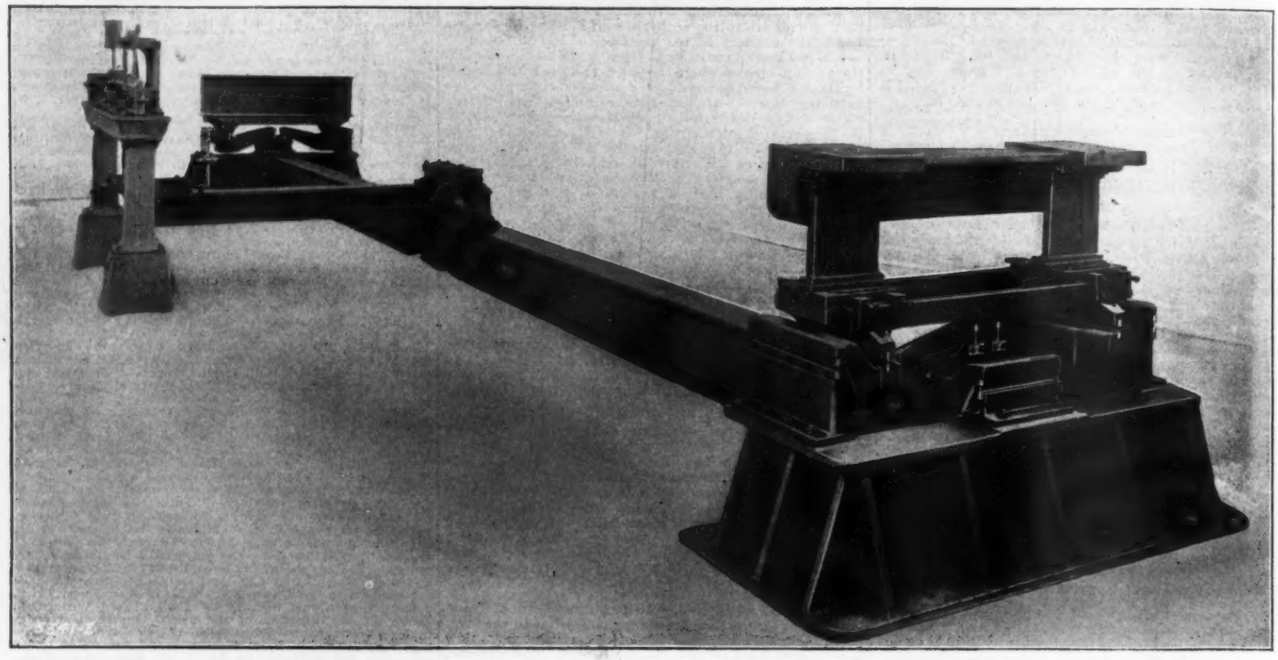


FIG. 6. MAIN, LONGITUDINAL AND TRANSVERSE EXTENSION LEVERS ASSEMBLED

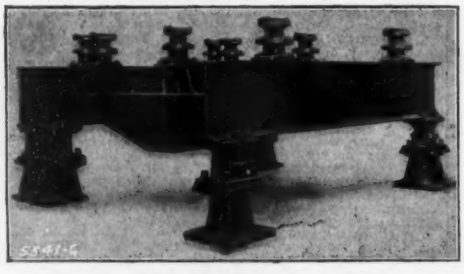


FIG. 7. ONE OF THE APPROACH SPANS.

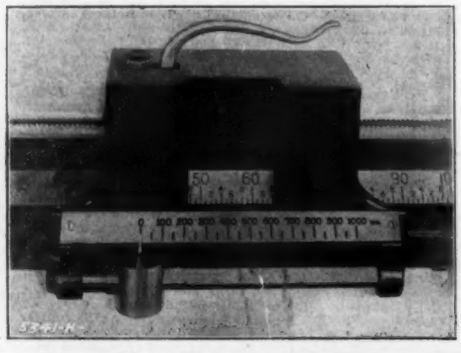


FIG. 9. BEAM POISE.

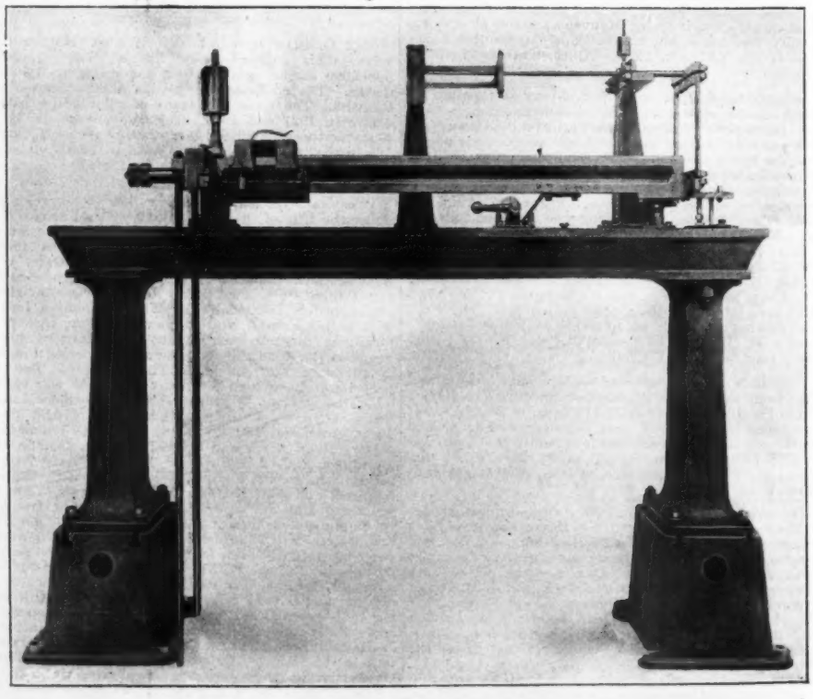


FIG. 8. WEIGHBEAM OUTFIT.

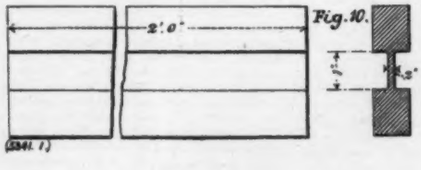


Fig. 10.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willimett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia, Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaughnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12 Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Longstreet.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue.
For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2 9 6
For Canada—	
Thin paper copies	£2 5 0
Thick " "	£2 9 6
For all other places abroad—	
Thin paper copies	£2 9 6
Thick " "	£2 14 0

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.
All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—8663 and 8508 GERRARD.

CONTENTS.

	PAGE
Literature	243
Books Received	244
The State of China from an Engineering Point of View	244
Substitutes in the German Electrical Industry	246
Continuous Milling Machine (*Illus.*)	249
Plate Fulcrum Track Weighbridge (*Illus.*)	251
The National Industrial Research Laboratory (*Illus.*)	252
The Physical Society of London	256
Notes from the North	256
Notes from South Yorkshire	256
Notes from Cleveland and the Northern Counties	257
Notes from the South-West	257
Gravity of the Shipping Situation	259
The National Physical Laboratory	260
Problems in Atomic Structure (*Illus.*)	261
Notes	262
The Prospects of an Aeroplane Mail Service	263
Industrial Notes	264
The Measurement of Current in Electrical Ignition Spark Circuits	265
The Financing of Industry	265
The Junior Institution of Engineers	265
North-Eastern Section of the Junior Institution of Engineers	265
National Alliance of Employers and Employed	265
Modern Developments in Gas Works Construction and Practice	266
Diagrams of Three Months' Fluctuations in the Prices of Metals	266
The Hardening and Tempering of Steel (*Illus.*)	267
Boiler Explosion at St. Buryan	270
ENGINEERING Patent Record (*Illus.*)	271

With a Two-Page Plate of a PLATE FULCRUM TRACK WEIGHBRIDGE FOR THE PENNSYLVANIA RAILROAD COMPANY.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

FOR NOTICES OF MEETINGS, SEE PAGE 257.

ENGINEERING.

FRIDAY, MARCH 8, 1918.

GRAVITY OF THE SHIPPING SITUATION.

THERE was a sharp contrast in the statement on the Navy Estimates made by the First Lord of the Admiralty on Tuesday in the House of Commons. The work of the Navy called for the highest commendation; that of the men engaged in mercantile shipbuilding was shown to be unsatisfactory. In the one case, there were shadows in the picture drawn; in the other the sunshine was rarely present. For the present we do not propose to follow Sir Eric Geddes in his review of sea operations, excepting only as they affect the submarine warfare, because that is directly associated with the main need of new shipping to ensure early success in our sea campaign. The German submarine is being defeated, but again we must assert the view that fuller information, even if it were not up to date, would have a heartening effect on the people. Certainly in the waters around the British Isles splendid results are being achieved by the anti-submarine operations of the British and American fleets, and we can accept the assurance of the First Lord, corroborated by Mr. Asquith, that, to use the latter's words, "the best brains, the most developed technical knowledge, the highest scientific reservoir of research and the highest practical experience" are being devoted to this problem. In the Mediterranean, however, there does not seem to have been the same co-ordination of effort, and the losses of merchant ships in this area—30 per cent. of the total—are disproportionate to the tonnage navigating the waters. This lack of co-ordination is inherent in a war where three or four nations are allied, as there is not the same unity of control. Thus the naval command in the Mediterranean rests with the French, and in the Adriatic with the Italians, British naval forces acting respectively under the French and Italian Admirals. We are glad to note that an allied naval council has got to work, and that Sir Eric Geddes was at their meeting at Rome. The result is that the British anti-submarine proposals put forward by our Commander-in-Chief in the Mediterranean have been accepted, and there is reason to hope that the same success against the German under-water attack, which is increasingly effective in the British area, will have a salutary influence in reducing losses in the Mediterranean. Another satisfactory feature is that the Greek Navy is soon to come into operations, as this navy is one of the best of those belonging to secondary or tertiary Powers Incidentally, also, satisfaction may be expressed with the fact that the Brazilian Navy will soon augment the allied forces in European waters, but whether in the Mediterranean or North Sea has not been disclosed. The only other point on which reference to naval operations need be made is the "tip and run" offensive operations of the German torpedo craft. These are inevitable, and up to a certain extent negligible. Viscount Jellicoe, in a recent speech, asked the people, when they were looking at small maps, to realise that the presence of a ship in the vast waters of the North Sea corresponded to a pin point in such maps as we are accustomed to consult. This alone shows how easy it is for a daring German commander to make an occasional incursion, with surface craft, into open seas, and, on dark nights, even into the Straits of Dover.

We come now to the more serious phase of the situation, that affecting the balance-sheet of mercantile shipbuilding. Mr. Asquith, in his reply, claimed that in 1915 our mercantile marine sea losses, due to hostile belligerent action or to submarine activity, had been made good by construction. In 1916 there was a loss on the balance. No doubt Mr. Asquith intended that some credit should be given to his Government for this state of affairs, but it is not enough to consider merely the balance between loss and replacement. It is imperative that consideration should be given rather to the tonnage available for oversea transport as distinct from the tonnage of the total fleet, since the greater part of it is withdrawn from effective peace service by the need of transport of men and material for our fighting forces, which, of course, is of primary importance. The absorption of tonnage for such war operations has been intensified, and, along with it, the greater activity and the unrestricted submarine operation of the enemy have resulted in a grave depletion in 1917 of the tonnage available for peace work.

There is certainly a greater need for intensive shipbuilding operations, and it cannot be said that the full capacity of our yards, either in respect of material, machinery or *personnel* is being utilised. It was anticipated that the output in 1917 would equal the merchant shipping output of the record year, 1913—namely, 1,920,000 tons—but the Chancellor of the Exchequer admitted that this expectation had not been realised, although the difference was less than 100,000 tons. In the last three months of 1917 the average monthly output was 140,000 tons; in January the output was 58,000 tons; and the February total is now estimated at nearly twice the output of January. This, however, the First Lord said is "only about two-thirds of what the same yards and fewer men have done in a month." We admit it is a mistake, in such engineering operations as extend over a long period, to take a month's work as a fair degree of comparison, because tonnage output can only be measured by launches, and even weather conditions may postpone the launch of vessels when the state of construction justifies their being floated. But when all allowance is made the situation must be regarded as grave. Sir Eric Geddes says that "the men in the yards are not working as if the life of the country depended on their exertions; nor are they working even as they did in the fourth quarter of last year." Unrest, a tendency to take holidays—and "we cannot afford holidays while there are food queues"—account for the slackening off in output. The First Lord made the statement that "employers also are not perhaps in all cases doing all that can be done to increase output." This statement he did not amplify, and thereby did injustice. Is this one of the cases indicative of a general practice, when blaming workmen to cast a slur also on the employer, with the simple object of "gilding the pill?" This has the effect of nullifying exhortation to increased effort. The men are most ready to fasten upon any statement which leads to recriminatory thought or speech, and unless Sir Eric had ample justification for his statement—in which case he ought to have produced his evidence—the bald remark made should have been withheld. The unrest of which he spoke was largely due to the 12½ per cent. bonus episode, because, as Mr. Barnes has so very properly and logically pointed out, it introduced an entirely new element in labour remuneration. Everyone—the Government, employers and the best of the workmen—are striving for the extension of the principle of payment by result, and the 12½ per cent. proposal seriously interfered with this very desirable stimulation to increased productive effort. The increase in holiday-taking is, in considerable measure, due to the payment of large sums to men, owing to awards being made retrospective. With such a windfall the worker needs no further inducement to take a

holiday. The condition of affairs is most unsatisfactory in the yards, especially on the Clyde, and it would be well if inquiry were instituted as to the cause, and especially as to what part Government control has in this state of affairs.

To stimulate the workmen it is necessary that they should fully realise the importance of their part in the war. There has been too much optimism. We accept the view that the destruction of German submarines, particularly in the seas surrounding these isles, is at a satisfactory and increasing rate and that there is hope for better results in the Mediterranean. We are told that we are sinking submarines "as fast as they have been built," and that in recent months the chances against a submarine returning from its voyage in home waters are about one in four or one in five. There is no doubt, too, that the loss of merchant shipping from belligerent action is decreasing. We fear that there is not always adequate care to prevent loss. With structural details and the bulkhead question we shall deal later. Sir Eric showed that ships were too prone to display lights whereby their presence could be detected at night, and this had induced the German submarine to keep well into the British coast. During the first months of the unrestricted submarine campaign, 50 per cent. of the losses in home waters occurred outside an area of 50 miles from the land, whilst only 21 per cent. occurred within 10 miles of the shore. This percentage, unlike others quoted, relates to the numbers of ships and not to tons. To-day, the losses outside an area of 50 miles from the land have fallen to 1 per cent. of the total, whilst the losses close in shore have risen to 61 per cent. The transfer of attacks nearer to our coasts is not only giving increasing opportunities of attacking the enemy by patrolling service and aircraft, but has an indirect advantage in that it is enabling us to salve many vessels which, if they had been attacked in the open sea, would have been lost, as assistance by salvage tugs would have been impracticable. Sir Eric showed that if the rate of loss of tonnage by submarine attack in the quarter July to September last had been maintained until the end of February, the shipping tonnage of the world would have been nearly 600,000 tons less than it is to-day. On the other hand, the Germans claim an enormously increasing rate of destruction. This progressive rate of exaggeration is, to use Sir Eric's phrase, "adopted in order to hearten enemy people." In the second quarter of last year this rate is twice that of the first quarter. The third and fourth quarters are roughly three and four times the first quarter's rate of exaggeration, and in the month of January more than four and a half times. As the Germans find it necessary thus to exaggerate the results, there is the greater reason for the publication of the tonnage of losses by our Government, and we are glad to note that the British Government hope to be able to induce our allies to favour the publication of tonnage losses. It is intended also to publish the tonnage launched, showing that produced by the respective districts. This latter will raise the spirit of emulation, but this is not sufficient for the purpose. In publishing the tonnage launched in each district there should also be stated, for comparison, the capacity for average tonnage production in the period given, so that it would be possible to estimate how nearly the result approximates to the possibility.

The finest effect of all, however, would be got by showing clearly the progress of the race between German destruction and British replacement. It may be objected that it may not be possible, say, at the end of March definitely to record the actual tonnage of shipping losses in that month, whereas it would be easy to state the actual tonnage launched in the same period. The comparison, however, could be made by showing the tonnage losses, say, in December against the tonnage replaced by the shipbuilders in March. This would at once place the workers in our shipbuilding yard in direct combat with the German U-boat commanders and crews. They would feel by the direct comparison of results that they were as effective belligerents as those carrying out anti-submarine operations. We are a sporting race, and nothing appeals to the working man so readily as competition where the result can be measured as closely as the progress of a Derby race. We can almost conceive the workmen betting on the results of the month, and also on the time when the rate of replacement would equal the rate of destruction. As the Germans are claiming more than they are entitled to, good would accrue by the publication, officially, of the tonnage by the British Government. It would help them to realise, as Sir Eric Geddes has repeatedly said, that the submarine menace is well in hand, although not yet defeated. In addition to being a sporting race, the British have always faced adversity with a stout heart. Food queues are a direct result of the withdrawal of tonnage from peace transport work, as well as of the destruction of merchant tonnage. The queues are most disheartening, but if the people were told accurately and honestly how our shipbuilding operations were progressing side by side with the growing evidence of German submarine failure, the morale of the nation would be improved greatly and the earnestness of the shipyard workers measured and credit or blame nationally bestowed. We are all willing to make sacrifices, but we wish to have the truth as far as this is consistent with the solid duty of the nation to win to final peace.

THE NATIONAL PHYSICAL LABORATORY.

In view of the very important changes which are about to be made in the organisation and control of the National Physical Laboratory, Sir Richard Glazebrooke's lectures at the Royal Institution last Tuesday, and on the 26th ult., are particularly timely. In his first lecture, which we reprint on page 252, the speaker reviewed the progress of the institution in question, from its early days at Kew up to date. The staff originally consisted of three scientific observers, and the total annual income was about 5,000*l*. At present the staff numbers upwards of 500, of whom 180 are women, and the income for the year which closes on March 31 next will be well over 100,000*l*. This figure may, however, convey too favourable an impression as to the actual financial position of the laboratory. The Government of the country has never frankly accepted the position that the undertaking was of first rate national importance and entitled accordingly to an adequate subsidy. Hence, since its inauguration the laboratory has, as far as financial responsibilities are concerned been virtually a private undertaking of the Royal Society, which would have had to make good out of its own funds any loss on working. Fortunately, however, the income from fees has throughout the whole existence of the laboratory been sufficient to supplement the inconsiderable annual grant doled out by the Treasury; but circumstances might at any time have arisen which would have involved the Royal Society in serious difficulties and the responsibility incurred was undoubtedly one from which it should have been relieved long ago.

Even our permanent officials were, however, compelled to recognise that a neglect of aeronautical research might endanger our existence as a nation. Further, funds were accordingly found for this, though we believe on a much less liberal basis than that adopted by certain foreign Governments. Fortunately for us the value of research work is not by any means in direct proportion to the expenditure incurred, and the laboratory was fortunate in securing the services of a number of very able young men at salaries much below their real intrinsic value. Sir Richard Glazebrook, in his lecture, recalls a gibe made when assistants were being advertised for. The comment made was that: "The scale of pay is certainly not extravagant. It is, however, possible that the duties will be correspondingly light." Some good men have, we believe, already left the laboratory, being offered more attractive terms elsewhere, and Sir Richard Glazebrook is certainly well entitled to demand that the scale and emoluments for the scientific servants of the country shall correspond to that in vogue in old-established departments of the civil service, where, in fact, a much lower standard of ability suffices for success. It was, we believe, Talleyrand who commented upon the little ability required for a prosperous career in an average Government department.

Though owing to the insistence of Lord Haldane, some provision was made for the pursuit of aeronautical studies at Teddington before the fateful summer of 1914, no similar success was attained by the committee which, under the chairmanship of the late Sir David Gill, urged on the authorities the importance of securing a home-made supply of optical glass. The official mind could not realise that in neglecting to study the production of optical glass in England they were seriously adding to the risks and dangers of war. Fortunately, owing to the work of Professor Jackson, supplemented by that accomplished at the National Physical Laboratory, real progress has been made in overcoming some of the more serious difficulties of the problem, and Sir Richard Glazebrook indicated that in the near future it might be possible to introduce changes of procedure which will greatly simplify manufacture and increase output. This question is intimately connected with that of refractories, the scientific study of which had been grossly neglected in this country in pre-war days. Much is, however, now being done in this connection both at the National Physical Laboratory and elsewhere.

Much important work has also been accomplished in the production of light alloys, and Sir Richard was able to quote a striking testimony to the value of the work done in this department; in the grant of 500*l*. made in recognition therefore by the British Aluminium Company.

The war which has emphasised so strikingly the transcendant value of the laboratory to the nation, has at the same time very seriously deranged the normal growth of its activities. As years went by the value of the laboratory was becoming more and more recognised by our manufacturers, as was testified by the steady increase in the annual receipts from fees. Under war conditions many of these slowly-established connections with industry have had to be severed, and the energies of the staff concentrated on war work. Indeed, had not the laboratory existed, we should have had to improvise some equivalent to this end. In the mere matter of gauges we had as a nation become almost entirely parasitic on foreign enterprise and skill. Sir Charles Parsons has stated, for example, that an inquiry conducted throughout the workshops of the North-East Coast revealed the existence of very few mechanics capable of accurate gauge work. The established standard of tolerance, even in the case of firms considered to have quite good tool-rooms, was 1 mil., which is no doubt a reasonable limit for heavy engineering work. But when the tool-room mechanics were suddenly asked to work to one-third of this limit, they proved to be without the requisite capacity. By sending selected men for training to the National Physical Laboratory the difficulty was surmounted and the country will, of course, continue to reap the benefit of this training in after-war conditions.

Similar benefits will accrue in other directions and in other industries, but this does not in any way obviate the fact that the commandeering of practically the whole resources of the laboratory in certain departments by the Admiralty and War Office has put an end to certain very valuable trade connections. Shipbuilders, for instance, who were liberally patronising the William Froude Memorial National Tank, have had to make other arrangements, and there is, of course, quite a possibility that these may be continued after the war, to the permanent loss of the Teddington establishment.

The impossibility of getting certain other work to be undertaken there under present conditions has also tended to promote the establishment of local centres for industrial research in a number of manufacturing areas, and these may continue to compete against Teddington after the war. There is, of course, much to be said in favour of these local laboratories, and we are glad to note that Sir Richard recognised this. They will provide independent centres of thought, and check any tendency which might arise in a single establishment to the stereotyping of methods and ideas. Moreover, they should also serve to widen the field for the selection of candidates capable of filling the principal appointments at Teddington, which, in

the interests of the nation should not be reserved wholly to the regular staff there.

The fact that these local centres of research have a legitimate *raison d'etre* does not however diminish the danger, that they may reduce the volume of work proffered to the National Physical Laboratory and leave it in a less favourable financial condition when the cessation of hostilities puts an end to the present press of work for the naval and military administrations.

The Royal Society has naturally, and very wisely, considered these risks too great for them to consent to remain financially responsible for the future of the National Physical Laboratory, and new arrangements have therefore had to be made. Of course, the ideal solution would be a Government guarantee, but until the national importance of the work done at the laboratory is appreciated at the Treasury as it should be, this course is hardly likely to commend itself to the official mind. The highly necessary reform of filling our principal administrative posts with men of a less specialised educational training must, however, be a work of years, and in the meantime the work at Teddington must be carried on. The arrangement made, which comes into effect on April 1 next, is that the scientific control of the laboratory will still be exercised by the Royal Society, but the property will be vested in the Imperial Trust for the Encouragement of Scientific and Industrial Research. The income of the laboratory, inclusive of fees, will be vested in and controlled by the Committee of the Privy Council for Scientific and Industrial Research. An executive committee will be appointed as before, on which representatives of the principal technical societies will be included. It is hoped in this way to assure financial stability, and still retain the benefit of the past close connection with the Royal Society. The work of the laboratory will be organised in eight different departments, each with its own superintendent and staff. A scheme has, moreover, been worked out to extend the system by which certain goods, such as thermometers, are now standardised and certified by the National Physical Laboratory. Work of this kind Sir Richard maintains cannot be satisfactorily carried out by a trade association, which certainly is unlikely to secure the confidence of customers, in the way that an entirely independent authority can do.

It is also important that this authority should be of national standing, if its certificates are to be accepted without demur by foreign countries. A start is being made with chemical apparatus, and a joint committee of users, makers, and testers, have laid down limits of error for the various classes of articles. Two classes of certificates will be issued. For the highest class each individual instrument will be tested at Teddington, but second-quality work will be dealt with by local inspectors. These are to be appointed by the laboratory and will inspect methods of manufacture and select specimens for test. If these are satisfactory, the maker will be allowed to mark the whole batch in some distinctive way. Possibly, in this connection, it may prove imperative to seek the assistance of Parliament. Not all manufacturers are honest men, and a fraudulent contractor can generally outwit the best of inspectors, if he considers the pecuniary gain to be worth the risk. Parliament should be appealed to to make this risk incommensurate with any possible gain.

Inspection of this kind, like much other work at the laboratory, is necessarily of a somewhat routine character not beyond the powers of any ordinarily intelligent and properly trained man. Nevertheless, it is of the utmost importance, both directly and indirectly, that men of great intellectual capacity shall be attracted to Teddington. This will only be possible if scope be afforded for original research work. Had not men of this type been on the staff, Teddington's marvellous record during the war would have been impossible. One novel problem after another was submitted to the National Physical Laboratory and solved rapidly and satisfactorily. Moreover, if the highest degree of precision is to be secured in any physical measurement, success is far more dependent upon the man than upon the mere equipment of accurate apparatus placed at his disposal. Hence, even on this ground alone it is most desirable that original research should occupy an important place in the work of the laboratory; but it is also undeniable that the direct value of such researches has already proved of great industrial importance, as in the case of the light alloys already mentioned, and the investigations now in progress on refractories cannot fail to be of equal or even greater value. The result of past neglect in the matter proved the fallacy of the aphorism that a contented mind is a continual feast. Our manufacturers were quite contented to let Germany have the bulk of the trade in the higher-class refractories, and could not make up their minds to finance the researches essential for effective competition. The war has changed this, and highly important researches are in progress now at different centres. Teddington has some special facilities for work of this kind, and may confidently be expected to play a predominate part in the solution of many of the difficult problems still unsolved.

PROBLEMS IN ATOMIC STRUCTURE.

ON Saturday afternoon last Sir J. J. Thomson, O.M., P.R.S., delivered, at the Royal Institution, the third lecture of his course on the above subject.

In commencing his discourse, the lecturer said that on the last occasion he had considered the question of the equilibrium of a number of electrons surrounding a positive charge, when the latter was assumed to be concentrated at a point. If the forces between the charges followed the ordinary law of varying as the inverse square of the distance, stable equilibrium would be impossible, though it became possible if the electrons rotated round the positive charge, or if at very small distances the law of the force was not that of the inverse square. He had assumed that in such cases the law was given by the relation,

$$\text{Effective force} = \frac{E\,e}{r^2} - \frac{k^2}{r^5} \quad . \quad . \quad (1)$$

It was, in short, not possible to build up a theory of the structure of the atom, merely from the assumption of point charges acting on each other according to the inverse square law, even although it was possible, as already stated, to secure stable equilibrium by setting the electrons in rotation. The difficulty which arose was that with equilibrium thus secured the radius of the orbit might be anything, whilst to account for the observed properties of the atom, the distances of the electrons from the centre must be sharply and definitely grouped at particular radii. It was necessary accordingly to introduce some other consideration than that of the equilibrium being maintained by the rotation of the electrons round the central charge under the influence of forces varying according to the law of the inverse square. The hypothesis that developed in the simplest way was represented by equation (1) *supra*, which included a term representing repulsion varying as the inverse cube of the distance between an electron and the positive charge. At very small distances the electron was accordingly repelled from the positive charge, at greater distances it was attracted, and it settled down accordingly into a position of equilibrium.

The hydrogen atom was regarded as having but one electron and one positive charge situated at the centre of the atom. An atom containing two electrons would have these located symmetrically at opposite sides of the centre and a little closer to this centre than when only one electron was present. Three electrons would occupy the corners of a triangle, and would be still closer to the central charge. Four electrons would occupy the corners of a tetrahedron, and would again be closer to the centre than the three. In short, as more and more electrons entered into the atom, the size of the latter shrank, each addition of an electron making the position of equilibrium closer to the centre. This rule held until the total number of electrons amounted to eight. If a ninth were then added, this would not join the group of eight which occupied the corners of a twisted cube, but would form a sort of detached satellite much further out. If a tenth were added, this also would remain outside the central group and, thus, by adding further electrons a second shell would be built up which again, however, could not contain more than eight electrons. The addition of a seventeenth would, in fact, start a third shell.

It would be seen that as the number of electrons was increased the atom passed through several stages. Beginning with one, the number could be progressively increased to eight, but the addition of a ninth started a new series, so that in all cases the outer layer of electrons never contained more than eight. This peculiarity recalled the periodic law in chemistry. If we imagined that the number of electrons increased with an increase of atomic weight, then the element corresponding to an inner shell of eight electrons, with one electron in an outer shell, would be lithium. As the atomic weight was increased more and more electrons would be added to this outer shell, but when the number reached eight the addition of another would start a third shell, in which, as in the case of lithium, there would be only one electron in the outermost layer. We then got sodium, with properties very analogous to those of lithium. Adding eight more electrons, a fourth shell was commenced, having again but one electron on the periphery of the atom, and we thus got to potassium. It would be seen that the structure which arose from the assumption represented by equation (1) gave a kind of reproduction of Mendeleef's periodic law, and he proposed, Sir Joseph continued, to develop some consequences of supposing that the number of electrons in the outside layer was equal to the positive valencies of the atom, whilst the negative valencies were equal to eight minus the number of positive valencies.

Suppose that the atoms were built up by the law assumed above, how would the size of the outer layer alter with the atomic weight? If the repulsion were constant, as the number of electrons increased from one to eight, the layer would get nearer and nearer the centre of the atom. Hence, although, as he had observed last time, the atomic volume was a slightly indefinite term, this atomic volume would shrink too. If the assumed law were right, therefore, we should expect that, as we proceeded in a chemical series from mono-valent to di-valent, and from di-valent to tri-valent atoms, then the atomic volume should diminish, since the outer layer of electrons shrank nearer and nearer in towards the centre with each increase in the valency. With but one layer and eight electrons in it, we got neon, which was followed by sodium, with which a new shell was started having but one electron in the outer ring. In this atom the positive charge was shielded by the inner layers of electrons, and was thus equivalent to but a single positive charge. The net electric force would thus be the same as before, and on starting the new outside layer with one electron there would be a sudden increase in the radius of the atom. If the assumed repulsion were independent of the total positive charge present, this radius for sodium would be exactly the same as that for lithium, and these two elements would have accordingly the same atomic volume.

It would be seen that, if we confined ourselves to one series of elements the atomic volume should, on the theory expressed by equation (1), diminish as we proceeded along each chemical series, and it should jump up on entering the next series.

Lately, the speaker proceeded, much attention had been paid to the study of atomic volumes, and Fig. 1 represented, the results arrived at by

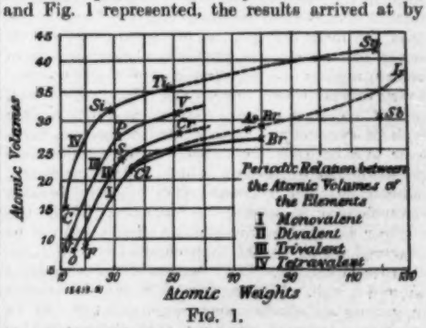


FIG. 1.

Mr. Lebas. These were deduced from a study of the hydrocarbons, and included, therefore, only such elements as combined with carbon. It would

be seen from the curves drawn that the atomic volume diminished as we passed from silicon to phosphorus, sulphur and chlorine, and was smallest with the latter electro-negative element at the end of the series. In the first set, again, Mr. Lebas did not confirm Lothar Meyer's minimum at carbon, but found that the atomic volume diminished as he passed from carbon to oxygen, which was represented in the diagram as having a smaller atomic volume even than fluorine. There was, however some little doubt as to whether this was really the case. Apart from this doubtful exception, the diagram showed that in each chemical series the atomic volume steadily diminished as the positive valency increased, and then jumped up again at the start of a new series.

The view put forward above had been suggested by a study of Mr. Lebas's diagram. One point arose of critical importance. We should expect when we passed into a new series with one electron in the outer layer that if the radius of this layer were the same as at the start of the preceding series, the properties of the two atoms would be identical. On the view in question, the electron population in the outer layer was always scanty. With one electron in an outer layer and eight in an inner layer the diameter of the outer ring was five times that of the inner shell. It would be necessary, therefore, to go much more than half-way through an atom to reach the inner layer, and a single outer electron was thus very isolated. If, therefore, such an isolated electron was situated at the same distance from the centre as the corresponding electron of the element at the start of the preceding series, we should expect that the properties of the two elements to be almost identical. We knew, indeed, that they were similar, but they were by no means identical. The point that arose was what was the origin of this difference in systems containing the same number of electrons in the outside layer. This introduced a point of very great importanse as to the mechanism at work.

In the foregoing it had been assumed that the repulsive force on the electron was independent of the gross amount of the positive charge present, so that an increase in the amount of positive electricity at the centre did not increase the repulsion on a single electron in the outer layer. As the repulsion depended upon the positive charge, this assumption represented a rather unlikely state of affairs, and it appeared more probable that as the positive charge at the centre increased so did the repulsive force. If that were so, the repulsion on a single electron in an outer layer would be greater when there were inner shells of electrons than in the contrary case. Its position of equilibrium would therefore be further away from the centre of the atom, and the new system with an additional inner shell would not be a mere repetition of a previous system. We could thus pass from the series headed by lithium to the sodium series, and in each successive series the size of the atom would be greater than that of the corresponding atom in the previous series. This conclusion agreed with observation, sodium having a greater atomic volume than lithium, and potassium than sodium.

One of the strongest arguments in favour of the view that positive and negative charges of electricity formed the structure of bodies was provided by Curie's discovery of piezo-electricity. Curie found that the mere deformation of certain crystals by stress electrified them, the charge being positive in certain regions and negative at others. It was not every crystal which showed the effect, which was, in fact, confined to forms characterised by a certain lack of symmetry. Quartz and tourmaline, however, were both effective. Slices cut from tourmaline perpendicular to the axis, which was always clearly defined by certain streaks parallel to it, became electrified if subjected to pressure. With the cheaper kinds of tourmaline the effect could not be observed owing to the high conductivity of these cheaper qualities, but transparent tourmaline showed it well. With quartz there was also trouble in getting satisfactory specimens. Quartz had an inveterate habit of twinning, with the result that charges of opposite sign were developed close together on the same face, thus neutralising each other. Nevertheless, slices of quartz could be obtained which showed the effect well, and Curie had used extensively, in his laboratory, the arrangement shown in Fig. 2. Here a slice

FIG. 2.

of quartz, suitably cut, was arranged so that it could be put under tension. The faces were silvered, one face being connected to an electrometer and the other to earth. By varying the pull on the quartz, a charge given to the electrometer from some other source could be neutralised, and the arrangement was a very convenient one for "null" methods of electrometry as, with practice, the spot of light could be kept steadily to zero by suitably adjusting the tension on the quartz. Tourmaline could not be used in the same way, but could be used to measure hydraulic pressures by the electrification developed when it was exposed to them. In this case quartz would not answer.

Recurring to equation (1), the lecturer said that it was useful to form some definite idea as to the origin of the repulsion represented by the second term. As an aid to specifying its nature as clearly as possible, it was convenient to regard it as due to something which he would call particles, but he did this merely for facilitating brevity of statement and for simplicity in reasoning. The word particle was, in short, to be taken in a Pickwickian sense, and he did not assume that these particles had mass or any other property than that of acting as a repellent. On this assumption the atom would consist of positive and negative electrons plus these particles, or units of repulsion, and in view of their purely hypothetical nature he would denote them by q ?.

Taking the simplest case, that of the hydrogen atom, if this consisted merely of one electron and one charge of positive electricity, it might be supposed that with this simple structure the behaviour of the atom would also be simple and have a simple spectrum. On this simple view it was difficult to explain how the actually very complicated spectrum of hydrogen was produced by the possible vibrations of the electron. Hydrogen gave, in fact, two spectra. The one contained a number of widely separated lines forming a series obeying Balmer's law. There was also a second spectrum which was full of lines, particularly in the region of the red. A portion of this second spectrum was represented in Fig. 3.

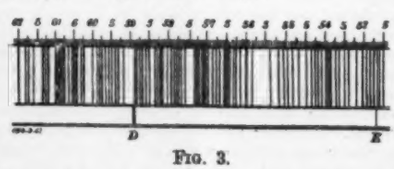


FIG. 3.

It would appear to be a formidable task to attempt to explain the existence of all these lines if we started merely with a single electron vibrating about its position of equilibrium. It reminded one of the old lines:

> . . . "Still the wonder grew,
> That one small head could carry all he knew."

If, however, the atom contained also these hypothetical repelling particles, there might be more of these associated with the central charge in some hydrogen atoms than in others. It was the repulsion which kept off the electron from the centre, and if the number of repellent particles varied we should get a series of hydrogen atoms of different sizes.

Suppose any one of these atoms was suddenly deprived of one of these units of repulsion. The electron would then jump closer in and settle down into a new orbit. It was, in his opinion, an hypothesis, deserving of further test, that the origin of the spectrum was to be attributed to the ejection of one of these repellent particles from the central core. The atom was previously in a steady state with its electron at a certain distance from the centre. On the ejection of a repellent particle this electron would now fall in and form a new atom radiating on the energy as it settled in its new position of equilibrium.

There was, he thought, a good deal to be said for supposing that in some way such as this the radiation of the atom was to be accounted for.

Dr. Bohr's theory of the origin of the spectrum had a considerable resemblance to the foregoing. Bohr regarded the spectrum as arising from the passage of hydrogen from one kind of atom to another kind of hydrogen atom. He introduced the idea that the moment of momentum of the electron circulating round the central charge suddenly jumped and changed by a unit. It was during this change that Bohr considered the radiation to take place. There was, as stated, a resemblance between this view and that put forward *supra*. The speaker, however, found a difficulty in following out how the radiation arose on Bohr's hypothesis, although it must be acknowledged that the results of Bohr's calculations were in striking agreement with experiment. For his own part, he got clearer ideas in imagining that the ejection of one of his hypothetical particles from the central core was responsible for the radiation of the atom. On this view there should be many kinds of hydrogen atoms varying with the number of the particles in the core.

It would be interesting to get direct evidence of the existence of these different kinds of hydrogen atoms. The spectroscopic evidence was insufficient. The only plan of attack available would seem to consist in measuring the energy needed to ionise the hydrogen atoms, that was to say, the energy required to tear out an electron. If this electron were a long way from the centre, less energy would be required than if it were closer in. Some measurements had been made, and there did seem to be indications of several stages of ionisation. Thus one stage was attained with 11 volts, and there was another stage which required 15 volts. He would not press the matter or say that a difference in the hydrogen atoms was the only possible interpretation of these results.

NOTES.

THE MODERN DYE-STUFF INDUSTRY.

Discoursing upon the subject of his life's work, at the Royal Institution last Friday, Professor Arthur R. Green, F.R.S., of Leeds, dwelt mainly upon the directions in which "the modern dye-stuff industry" had advanced, thanks chiefly to logical studies of structural chemistry. All these dyes, he explained, were aromatic compounds containing one or more benzene rings or hexagons, the corners of which were taken up by CH, atoms of carbon and hydrogen. Two combined rings made up the naphthalene molecule, three rings anthracene. Not all benzenoid compounds were coloured. Witt first, in 1876, attributed the colour to two groups of radicles: the chromophors, predisposing to colour, such as NO_2 (nitro group), NO.OH (nitroso), N = N (azo); and the auxochromes, intensifying the colour, such as OH (hydroxyl), NH_2 (amide), and other alkyl groups. Modern views associated colour rather with a peculiar unsaturated condition, the

quinonoid structure, in which two hydrogen atoms of the ring were replaced by oxygen atoms; these oxygen atoms might be in the ortho, or in the para position, and they then differed also as to the bonds between the atoms. Not all quinonoids were coloured either, and it was frequently merely a question of bondage and of conditions (nature of solvent, acidity, alkalinity, temperature) whether a compound was benzenoid or quinonoid. Thus, Professor Green demonstrated, an aqueous solution of rhodamine (red) yielded its colour to benzene when shaken with it; the benzene settling over the turbid mixture was colourless; yet, when a piece of blotting paper was dipped into this solution, the paper turned red in a few minutes, because the benzene evaporated more rapidly than the little water it had taken up. Being unsaturated the dyes united with atoms of hydrogens and were converted into colourless leucocompounds which could easily be oxidised to the coloured compounds again by exposure to air; this regeneration was very easy with the ortho compounds, but not with azo dyes. The technically important properties—shade, fastness to light and to soap, affinity for vegetable or animal fibre in basic, acid or neutral baths, the need of mordants to fix the dye upon the fibre, &c., seemed to depend more upon particular radicles than upon structure. Thus dyes containing the acid SO_3H group or the carboxyl group CO.OH, were salts (generally sodium salts) of these acids; basic dyes were salts (hydrochlorides, sulphates, &c.) containing the NH_2 and substituted groups; dyes containing the OH group formed coloured lakes with the heavy metals. To increase the fastness, the compounds were "weighted" with heavy radicles like C_6H_5; Holloway applied this to calico printing. The azo and diazo dyes (direct cotton dyes), both discovered by Peter Gries since 1864, were known in thousands of compounds, more numerous than all the others together. From mixtures, cotton would take up one dye, wool another, it was shown. The indigo dyes, whose synthesis A. von Baeyer (who died in 1917) worked out, were soluble and colourless in the reduced condition, but became insoluble and coloured by oxidation. The yellow primuline, on the other hand, turned blue by reduction, but yellow again by oxidation. Professor Green demonstrated a new, very simple synthesis of indigo from orthonitrobenzaldehyde, acetone and caustic soda, not yet commercial, however; everything looked easy in his elegant demonstrations. Cotton could be dyed direct and coupled with other dyes in the fibre. The Tyrian purple which the Romans extracted from certain molluscs to dye their togas was synthetised by Friedländer in 1909. The sulphide dyes, the simple preparation of which Vidal discovered in 1893, had become very important, though their constitution was not yet fully settled. This branch, the indigo processes and several other dye manufactures, had now been successfully established in England. To put the industry on a firm footing, Professor Green concluded, chemical study should be encouraged and the chemists better paid, and State aid might be needed both for the study and the industry.

Electrical and Thermal Conductivity.

The best conductors of heat are generally also the best conductors of electricity, and the ratio of the thermal conductivity, k, to the electrical conductivity σ, has, for the same temperature, nearly the same value for all metals. According to the law of Wiedemann-Franz this ratio is: $k/\sigma = \frac{4}{3}\left(\frac{R}{e}\right)^2 T$ at 18 deg. C., where R is the gas constant, e the electric charge carried by the univalent ion, and T the absolute temperature. The law holds well for pure metals, less well for alloys, and not at all for poor conductors. The ratio should, with varying temperatures, be proportional to the absolute temperature, but the law has not yet been confirmed by many series of observations covering wide ranges of temperature. A good many experimental determinations have been made, notably those in the Reichsanstalt, by Jäger and Dieselhorst, to whose table Sir J. J. Thomson referred in his remarkable lecture on "The Conductivity of Metals," delivered in May, 1915, before the Institute of Metals.* Very little has been done so far, however, to ascertain whether there is any discontinuity in the ratio near the melting-point of a metal. A few years ago, A. W. Porter and F. Simeon† examined mercury and sodium with this object. They charged vertical tubes with either of these metals and heated and cooled the tubes in such a way that the upper portion of the metal was liquid, when the lower portion was still solid, and they determined the temperature gradient: they did not observe any discontinuity. A similar examination of two other metals has been conducted at the Princeton University, New Jersey, U.S.A., by Dr. E. Northrup and Mr. F. R. Pratt (Journal of the Franklin Institute, November, 1917). They selected two metals which were known to differ in the important respect, that the one, tin, becomes a poorer electric conductor when fusing, whilst the other, bismuth, conducts electricity better when fused than when solid; the electric resistance changes which these two metals undergo on fusing are in the opposite sense, whilst with sodium and mercury the changes are in the same sense. If the Wiedemann-Franz law held, the change in the thermal conductivities of tin and bismuth should also be in the opposite sense; and this was confirmed. In previous experiments Northrup had established that the specific resistance of tin changed from 22.0 microhms just before fusion to 47.4 microhms after fusion, this ratio being 2.154; bismuth, on the other hand, had a resistance of 267 microhms before fusion, and of 127.5 microhms after fusion, that ratio being 0.477. The thermal experiments were conducted by inserting a cylindrical block of the metal, tin or bismuth, between two similar blocks of steel, the upper cylinder of steel being heated by a rod of copper (surrounded by an electric furnace) resting on its upper surface, and the lower steel cylinder being inserted in a water bath kept at 100 deg. C.; the block of metal under test was surrounded by a cylinder of alberene, and thermocouples were inserted both in the metal and in the steel. These couples were 2 cm. or 3 cm. apart in the metal and in the steel, and with their aid it was possible to make sure that the quantity of heat flowing per square centimetre between the two temperature-points in the metal under test and in the steel cylinder was steady and nearly the same during the time of taking an observation. A great many observations were taken for both the metals, and the authors claim to have used every precaution; it does not appear, however, that their observations, which extended from 202 deg. C. up to 310 deg. C. for tin, and for bismuth from 180.7 deg. up to 272.8 deg. were taken also close to the melting-points. In the case of tin there is a break between 222 deg. and 285 deg. (melting-point, not stated, 232 deg. C.), and in the case of bismuth (melting-point 269 deg.) a similar break between 237 deg. and 306 deg. The general conclusion is that the law of Wiedemann-Franz holds for tin and bismuth also when they pass through a change of state of aggregation. We should mention, however, that the values for the Wiedemann-Franz ratio, which Northrup quotes from Campbell's "Modern Electric Theory," do not agree with the values which Sir J. J. Thomson gave in his lecture.

New German Shipyard.—A company with a capital of 5,000,000 marks has been formed for the purpose of starting a shipyard at Nordenham, under the style of the Oldenburg yard. A suitable site with a water frontage of 1,300 ft. has been secured, and the new yard will principally undertake the building of special types of fishing vessels.

The Bochum Union.—In the course of a recent extraordinary general meeting, this concern agreed to increase the capital from 36,000,000 marks to 45,000,000 marks. Extensions during the last few years had entailed an outlay of 20,000,000 marks, and the increase in stocks of raw materials, which had been found necessary represented an additional sum of 17,000,000 marks. Owing to the high dividends, the sums to be set aside for welfare institutions had risen very materially. Since the last increase of capital, in 1912, the turnover had been trebled. The company was fully employed; prospects were exceedingly satisfactory and the deliveries for the current year exceeded those for the corresponding period of the previous year.

* See Engineering, May 26, 1915, page 577.
† See Engineering, April 16, 1915, page 431.

THE PROSPECTS OF AN AEROPLANE MAIL SERVICE.

First-Lieutenant Krause-Jensen, a gallant Danish officer who has served with much distinction as a military aeronaut in the French army, has on a recent visit to Denmark spoken with intense enthusiasm on the future of the aeroplane after the war. He looks upon the establishment of a number of fixed routes immediately peace is restored, and considers an aeroplane London-Paris mail and passenger service certain to materialise. People, he says, consider flying with too much solemnity, in times of peace it entails no greater risks than does the riding of a motor cycle. There is not an aeroplane factory in France which is not prepared for a tremendous development of civil aeroplane services after the war. The aeroplane has also a great future for sporting purposes.

In the meantime, the Danish Aeronautic Society is working hard in the interest of an aeroplane mail service. An expert committee has travelled the country and has also studied the question theoretically, with the view of establishing landing stations and furthering legislation dealing with all the many points involved. Negotiations are pending with 39 Danish municipalities in the matter of the construction of landing stations. At a number of towns it is proposed to erect hangars 1,300 ft. square at the landing places. Trial aeroplane mail services will, it is stated, be undertaken during the forthcoming spring or summer by military aeronauts, special machines to be built for the purpose. The Aeronautical Society has nothing to do with the mercantile side of the matter, which, in the meantime, has been taken up by two aeroplane traffic companies, and several routes have already been mapped out, including one Copenhagen–Odense–Fredericia–Esbjerg, one Copenhagen–Kallundborg–Aarhus, and a third Copenhagen–Aalborg. A service, Copenhagen–Gothenburg–Christiania, is also planned. The traffic will be worked partly by aeroplanes and partly by hydroplanes.

The Danish Aeronautic Society is also interested in the publication of an "air pilot," with particulars of all landing places and other information of international aeroplane interest.

Voices are also raised against the above plans, and at a meeting of the Society of Danish Engineers, exhaustive criticism was put forward, principally based upon the cost and the unreliability of an aeroplane mail service. One of the critics, however, recommended that a trial service be established on the Copenhagen–Kallundborg–Aarhus line.

In other countries experience seems to favour the optimistic views, and there are stated to be regular aeroplane mail services in France, Algiers, Italy and America; in the latter country there were said to be 37 aeroplane mail lines in operation at the close of last year. In Italy there has, for six months or more, been a regular aeroplane service between Rome and Turin, and the Italian postal department is desirous of establishing regular aeroplane mail services all over Italy, and to the Mediterranean Colonies. A hydroplane line between Sardinia and the Italian Continent is already in operation. About 400 lb. of letters are conveyed every day by a hydro-aeroplane, having fixed hours for departure and arrival. In France, the establishment of a similar line between Corsica and the French Continent has been planned, and there is also said to be a scheme in consideration for establishing an aeroplane line between France and Timbuctoo; this trip is calculated to take some 30 hours. In Japan, further, much interest is evinced in the development of the aeroplane.

Disabled Soldiers and Sailors (Workmen's Compensation) Committee.—The Home Secretary has appointed a committee to consider and report whether any special provision should be made in the case of disabled soldiers and sailors returning to civil employment in regard to the payment of compensation under the Workmen's Compensation Act. The secretary of the committee is Mr. G. R. A. Buckland, to whom any communications on the subject may be addressed at the Home Office, Whitehall, London, S.W. 1.

Non-Ferrous Metals.—The President of the Board of Trade has appointed Sir Dudley Stewart Smith, K.C. (chairman), Sir Harold Elverston, M.P., and Mr. H. J. Mackinder, M.P., to be a committee to examine all applications for licences under the Non-Ferrous Metal Industry Act, 1918, and to report to the Board of Trade thereon. The rules made by the Board of Trade under the Act, which prescribe amongst other things the procedure to be followed in making applications for licences, will appear in this week's issue of *The Board of Trade Journal*, in the London, Edinburgh and Dublin *Gazettes*, and will also be obtainable from the Stationery Office.

British War Photographs in Colour.—At the Grafton Galleries, Grafton-street, Bond-street, London, there is an exhibition of British war photographs in colours. It is a wonderful revelation of the hardships, the cheerfulness, and also the frightfulness which are found on the battlefield and behind it. One of the photographs is said to be the largest ever made, and depicts a tank, wonderfully camouflaged, and other objects to be seen in an advance on the Western front. The colouring of the photographs is exceedingly good, and gives them an air of reality far beyond what they would otherwise have. The picture will repay a visit, and the proceeds are to be devoted to military charities.

INDUSTRIAL NOTES.

SPEAKING at Exeter last Saturday on the problem of demobilisation, the Hon. G. H. Roberts, M.P., Minister of Labour said that demobilisation must be gradual. He would rather retain men in the army some months more than was absolutely necessary than that men should join the ranks of the unemployed. A board of eminent economists had been set up by the Government to consider the practical course of trade after the war; it was known that there would be a tremendous scope for employment after the war, and the Ministry was doing its best to see that the country had all the available supplies. He hoped to give every man demobilised a reasonable chance of employment within four weeks of discharge, and he believed men would use this four weeks in recreation. He hoped there would be industrial harmony during the period of reconstruction after the war.

During the coming months he was going to ask Parliament far larger powers in the way of extending the Trade Board system. They meant to see that after the war many conditions which existed before the war were abolished for all time, and that every honest, willing worker could gain a decent and tolerable existence. He was hopeful that the Ministry of Labour would have powers whereby they could bring under the Trade Board system any trade in the country in which a living wage was not guaranteed. Then it was proposed to establish industrial councils for every trade in the country. These councils would be composed of both employers and employed, and he hoped that by means of these councils consideration of trade affairs would be for ever removed out of the cockpit of party politics.

In conclusion, he solemnly warned his hearers that the country would be hardly and severely tested during the next few months Food especially would be scarce. He was not going to be a party to labour embarking on forlorn hopes. He intended to watch the stars but also his steps, and to be satisfied that the next step was not going simply to mean that they were slipping backward, but that they were making progress, and not likely to lose that for which they had contended.

In the course of an article in *The Federationist*, Mr. W. A. Appleton, after reviewing the relations which have existed for centuries between employers and employees, says that the present hostility shown by the workman has some justification. The workman realises, on the other hand, that the war has broken down many barriers, that a common intercourse with danger and death has stripped employers and workmen of many misconceptions and has brought the manhood in each into closer communion. The workman fears, however, that as the cause of the change passes, so the effect will diminish and that attempts will be made to reimpose the old relationships. If one says that the cost of the change has been too tremendous for the effects easily to diminish, then the workman asks questions which are barbed with the experience of the past. Centuries have been occupied in breeding the distrust which exists, and only a gigantic effort on the part of the employer and of that other class which neither employs nor is employed in the ordinary acceptance of the term, can convince the workman that the change is real and permanent and that from henceforth there shall be at least an attempt to give to each man and to each woman his or her honest dues.

The new spirit which such a conviction would beget would be favourable to a commonsense reconstruction of all the relations existing between capital and labour. A new spirit is necessary; for, while capital has adhered to the spirit of what is known as the Manchester school, labour has, rather blindly and without analysis, accepted many of the ideas as expressed by Karl Marx. If both sides could realise that success depends upon the combination of materials, mentalities and muscle, it would be possible to approach the future with some degree of confidence.

Dealing with various groups of reformers, Mr. Appleton adds that the institution of a system of direct management of industry and commerce by the workers engaged in the workshops has many advocates, but a departure on these lines could not be regarded as a course likely to secure the best post-war results. This demand is of political rather than industrial origin. It involves an immediate and non-compensatory appropriation of capital and wealth. It assumes a knowledge not merely of industrial processes, but of commercial enterprise and international exchanges. Mr. Appleton has met some workmen who hold these views. They are admirable workmen; many of them are intelligent, and some of them possess knowledge, but he cannot say that any one of the advocates of this method he has met is at once an admirable workman, an intelligent person and possesses an effective knowledge or understanding of the international character of trade, and that experience which is necessary to make international trade a success. Much of the trouble arises from the mistaken notion that trade is mainly a national and internal matter, when, as a matter of fact, much of the wealth that Britain has enjoyed and much of the capital she has stored up, have been derived from commerce and overseas trade. Some of the men he knows are intelligent enough, given time, to deal with these problems in a satisfactory manner; but at the end of the war events will move very rapidly, and the country which depends upon untried methods and inexperienced men will incur very grave risks.

The Engineering and Shipbuilding Trades Central Advisory Committee (Operatives) which advise and assist the Ministry of Labour on questions arising in the administration of the Employment Exchanges, which affect workpeople in those trades, held their sixth meeting at 10.30 a.m. on Thursday, February 28. The committee considered, among other subjects, a proposal that operatives seeking employment in highly-skilled trades should present either their indentures, a record from their trade union, or a note from the employers with whom they served their time. After discussion, it was unanimously agreed that the committee should accept the principle of the proposal and should invite the corresponding committee of employers' representatives to consider it in detail at a joint meeting.

The following are some recent decisions given by the Committee on Production and the Special Arbitration Tribunal, on cases which have been referred to them by the Ministry of Labour, including cases arising out of the Orders under which a bonus to munition workers has been given:—Motormen and conductors (the Birmingham and Midland Tramways Joint Committee): The motormen and male conductors concerned, aged 18 and over, are to receive 16*s.* per week over their pre-war wages from January 1, 1916. Foremen charge hands and electro-technical assistants (Messrs. Robert Paul, London): The men concerned, aged 18 and over, are to receive, from first pay in December, such further advances as will bring the increases on pre-war rates to 20*s.* per week. Bricklayers (Glasgow and neighbourhood): The men concerned on munitions work are to receive an advance of 1*d.* per hour, making 1*s.* 2*d.* an hour in all from first pay following December 21, 1917; in addition, those over 21 are to receive a bonus of 12½ per cent. on earnings from first pay after January 1, 1917. Galvanisers, &c. (Messrs. Smith and McLean, Clyde Galvanising Works, Glasgow): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. from January 1, 1917. Electricians (Metropolitan Electric Tramways, Limited, and London United Tramways, Limited): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. on earnings from first pay after January 1, 1918. Dock labourers (Ayrshire Harbour Authorities): The men concerned aged 18 years and over are to receive the following advances—(1) ores and limestone, ½*d.* a ton; (2) coal trimmers, ½*d.* a ton; (3) weekly paid men, 5*s.* a week; (4) tipper, 1*d.* an hour; (5) hatchmouthmen, ½*d.* an hour. Youths are to receive half the amounts awarded above. Building trade operatives (construction of Government buildings): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. on earnings from first pay in January, 1918. The award applies to men in the employment of the Ministry of Munitions, Air Ministry, Office of Works, Admiralty and War Office. In the case of men not in the direct employment of these departments, the departments are to authorise their contractors to pay the advances to the men in the employ of the contractors engaged upon the erection of buildings for the departments. Boiler and pipe coverers (Messrs. Reid Macfarlane and Co., Limited, Belfast): Plain time workers are to receive a bonus of 12½ per cent. from first pay following January 1, 1918. Anvil and vice-makers (National Employers' Federation): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. on earnings from first pay in January, 1918. Moulders (Messrs. Brooks and Doxey, Limited): Moulders, plate and machine moulders, on munitions work, working on a piece basis and receiving time rates, are to receive a bonus of 7½ per cent. on earnings from first pay in January, 1918. Horse-nail trade (the Capewell Horse Nail Company, Limited): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. from January 1, 1918. Spelter workers (Spelter and Lead Works, South Wales): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. on earnings from first pay in January, 1918. Accumulator manufacturers (British Electrical and Allied Manufacturers' Association): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. on earnings from first pay in January, 1918. Boiler scalers (Glasgow): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. on earnings from first pay week after February 20, 1918.

The sixteenth ordinary meeting of the shareholders of the Manchester Ship Canal Company was held in Manchester, on February 27. The chairman of directors, Mr. W. C. Bacon, presided. In the course of his speech, stated that in the early part of the war a large number—nearly 2,000—of the company's employees enlisted or were called up, besides numbers of casual men of whom the company have no record. The result was that in common with other ports Manchester had suffered at times from the shortage of labour, but, as stated in the report, although this had necessarily retarded the loading and discharging of vessels, the port and canal had been kept practically free from congestion throughout the year. The short supply of labour had been supplemented by contingents from Transport Workers' Battalions.

Additional war allowances had been granted to the company's Ship Canal employees on three occasions during the past year—in March, August and December. When he last addressed the shareholders, the company were paying 8*s.* 8*d.* per week war allowance to the permanent men and 2¾*d.* per hour war allowance to the casual men. To-day they were paying, speaking generally, 1*l.* 1*s.* per week war allowance to the permanent men, and 6¼*d.* per hour—equal to 1*l.* 6*s.* 6*d.* per week of 49 hours—war allowance to the casual men, and something additional for overtime. There were other minor concessions which added further to the expense. When the meeting remember that, including dock labour, the company employed between 7,000 and 8,000 men, excluding the Bridgewater Canals, it would be realised what a serious burden this was upon the company, and the anxiety felt by the directors in regard to the matter.

To meet this heavy burden and the continued increase in cost of materials, coal and other stores, as well as some anticipated diminution in the volume of traffic, the tolls, rates and other charges had to be correspondingly increased. As stated in the report, this course was adopted in April, August and December. Many of the toll charges were now above the maxima authorised by the company's Acts of Parliament, and others had reached the maxima. To enable the maxima to be exceeded the authority of the Board of Trade was obtained under the Defence of the Realm Regulations to the extent of 30 per cent. above the statutory maxima.

In order to create a corps of eminently efficient engineers for the new type of fast freighters now building for the American merchant marine, says the *Marine Journal*, New York, the recruiting service of the United States Shipping Board has arranged to give these men an opportunity to visit the works where the engines of the geared-turbine type are being built, and allow each chief engineer to follow his own engine through its construction and then through its erection on board ship, while being paid for his services and receiving an adequate allowance for expenses. The Shipping Board is very anxious to welcome assistant engineers who wish to obtain a chief's licence to any of its eight schools. Official announcement has also been made that all students entering the Shipping Board schools for deck officers and engineers will be exempted from military duty and will remain so as long as they pursue the calling for which the school fits them.

BRITISH INDUSTRIES FAIR, 1918.—The fourth British Industries Fair organised by the Board of Trade since the outbreak of war, will be opened in the Pennington-street premises of the London Dock on Monday next, the 11th inst. The building in which the fair will be held this year is situated within 12 minutes' walk of Mark Lane Station, on the Underground Railway, and a service of motor omnibuses will ply between Mark Lane Station and the fair. In order to avoid any possible interference with the production of military requirements, the fair has again been confined to the following industries, viz.: Pottery, glass, stationery, paper, printing, fancy goods and toys. As in former years, the right to exhibit has been confined to manufacturers, and some 425 firms are exhibiting. Although the number of exhibitors is approximately the same as last year, the area covered by the forthcoming fair is very much larger than in the case of any of the previous fairs, and, therefore, manufacturers will be able to display their goods to better advantage. In spite, however, of this increase in area, the whole of the space available was allotted to manufacturers before Christmas, and it has unfortunately proved impossible to accommodate a number of firms which had omitted to apply for space in good time. Admission to the fair is again confined to *bona fide* trade buyers, and invitations have been issued by the Board of Trade direct to over 60,000 firms in this country. Any firms which have not yet received an invitation, and desire to visit the fair, should apply for a card of admission to the Director, British Industries Fair, Board of Trade, 10, Basinghall-street, E.C. 2.

THE MEASUREMENT OF CURRENT IN ELECTRICAL IGNITION SPARK CIRCUITS.

To the Editor of Engineering.

SIR,—I cannot help feeling that Dr. Bairsto and I are more in agreement than would appear from our letters. But there is probably this difference between us. He seems to be so alive to the great complexity of the magnetic spark current that he doubts the possibility of anyone being able to make a useful measurement of it. I take up the attitude that as such a measurement is necessary it is imperative to attempt a solution, and in so doing the instrument which gives the results which are of the greatest practical usefulness is the one that should be adopted. After investigating many devices of my own and all the instruments of other workers that I know of, I have come to the conclusion that the instrument described in my article does give just those results which are helpful to the investigator of ignition apparatus. I quite agree with Dr. Bairsto that it is possible to arrange experiments in which voltage and current indications increase and decrease together. I have an instrument whose indications proceed in this way. But this does not disprove the statement of mine which Dr. Bairsto quotes. To disprove that statement it is first necessary to show that the instrument readings to which he refers correspond to known properties of the spark discharge, and that those properties are the ones which best determine the practical capabilities of the spark generator. This involves the formation of *a priori* ideas, a process to which Dr. Bairsto is apparently averse.

Yours truly,
J. D. MORGAN.

The Marks and Clerk Laboratory, 13, Temple-street, Birmingham, March 2, 1918.

THE FINANCING OF INDUSTRY.

To the Editor of Engineering.

SIR,—The amalgamation of some of the big joint stock banks has created a great deal of discussion, and even hostile criticism, based upon a somewhat superficial point of view of the functions of the banks. When men like Sir Edward Holden and other prominent bank directors decide to amalgamate their companies, it is not for the purpose of grasping more profits or financial power, but most likely because these men—who hold, so to speak, the hand or the financial pulse of the country—realise the necessity of combination and consolidation of the financial interests to withstand the shock which the changing over from war conditions to peace is bound to produce. The financial system is essentially a dynamic system in which crises are caused by the changing from the one condition to the other, but when the change has taken place, even what may be considered a most abnormal condition, such as war, can bring apparent prosperity. An essential function of the big banks is to be the financial flywheels that absorb the shocks, and the greater their moment of inertia, or the mass of capital they control, the smoother the machinery will run.

A very common complaint against the banks is that they are not pliable or "modern" enough in their methods, particularly compared with Continental banks. That reproach is also, in my opinion, groundless, having regard to the constitution of the banks. Take the case of one of the large joint stock banks. Its subscribed (not paid-up) capital is 4,000,000*l*. Its deposits are 80,000,000*l*; and, bear in mind, that the bank virtually acts as trustee for these 80,000,000*l*., which forms the 95 per cent. of fund with which the bank operates. The bank has got to reckon on the risk that it may suddenly have to hand back at short notice the major part of this capital entrusted to its care; which compels the bank, if it is to enjoy a reputation for solidity, to exercise the greatest caution in the loans it grants to borrowers. Therefore the fundamental principle in joint stock banks is that they are short-term loan institutions, and never can be anything else except by enlarging their share capital to such enormous dimensions that they would become unwieldy and dangerous to handle.

To industry and agriculture (and many contend that the dividing line between these two is not so sharp as most people think; in fact, both are sections of our economic main factor, viz., Production) the question of long-term loans is of vital importance, much more so than to the pure merchanting business. The merchant who deals in goods already produced and never has had any difficulty in getting his transactions financed by the banks, as there is a very high security, namely, the goods itself, for the money lent to complete the transaction. The producer has, on the other hand, got to sink such a considerable amount of capital in land, building works, wages, raw material, before he sees a return, that he is forced to seek the long-term loans, which now is generally done by forming a limited liability company. A share in a company is really nothing but a receipt for a loan—unredeemable and carrying the "adventure" interest. That banks cannot lend out their depositors' money in such unredeemable loans is too obvious to need further comment, but it might be of some interest to consider if there is not another form of financing on a long-term basis which does not participate in the "adventure" profit, and at the same time offers the highest security to the lender. This form of financing is known as the Credit Corporation system, and I shall shortly describe how it works and give a few examples of the success it has attained. A credit corporation is an association of borrowers who, through the corporation, obtains loans (long-term with fixed interest) on the basis of their collateral security of tangible assets (immobilia). The system which I have had occasion to study closely in Denmark has attained a wonderful success, and enabled a small country like Denmark (2,750,000 inhabitants) to raise over 100,000,000*l*. (1,800,000,000 kroner) for production purposes without impairing the strength of the banks or savings banks. The corporation does not advance cash against the security handed over by the borrower, but its bonds at face value, and the borrower sells these bonds in the open market, obtaining a price that fluctuates slightly according to the prevailing money rate, and always swings round a point determined by the value of security the public places on the corporation. The corporation is *not* a bank—it does not receive money on deposit, but some banks have what is called a "Hypothet Department," entirely apart from their ordinary banking business. The credit corporation receives the interest paid by the borrower and pays the dividend on the bond. The borrower pays, in addition to his fixed annual interest, a certain small percentage to cover amortisation of his loan—and his contribution towards reserve fund and administration. The interest is about 3½ per cent., 4 per cent. to 5 per cent., and the amortisation is generally fixed as a maximum of sixty years' repayment for real estate and twenty-five to thirty years for industrial property. The reserve fund is, as a rule, 4 per cent. to 5 per cent. of the bonds issued, and the market value of the credit corporation's bonds is about equal to Government bonds—in some cases even higher. No credit corporation is allowed to have bonds issued beyond the capital on actual mortgage.

The question arises—Will such institution have any prospect of succeeding in this country? That is a point which I do not pretend to be competent to judge; but it might be of interest to have the matter thoroughly investigated. Together with a few friends I am now actively engaged in collecting data, particularly as to what experience has been gained in countries where it has stood the test of time. To any one desirous of obtaining what further information we possess at this juncture we shall be pleased to reply to any query.

Yours respectfully,
J. J. LASSEN.

Imperial House, Kingsway, March 4, 1918.

THE JUNIOR INSTITUTION OF ENGINEERS.

To the Editor of Engineering.

SIR,—Your correspondence upon this question should do much to arouse the sleeping sections of most of our professional institutions.

Most of these institutions have examinations, to pass which young engineers work very hard. When a young man is successful in passing his status is considered by a senior body of the Institution, and in eight cases out of ten he is deprived of the honour gained, by his heavy studies, until he has attained a certain age. If a young engineer is capable of passing a set test in any branch of engineering, he would be considered capable by engineers of his own age, but with the actual setters of the test he is considered incapable, although he has passed the test.

This leads us to a very serious state of affairs, which suggests that juniors, although qualified to use senior degrees, by virtue of having passed the necessary examination, are kept in a lower category, to be called upon if required, or cast out if not required. No doubt a great ocean of prejudice exists between juniors and seniors caused by the fears of the latter section.

It is for the elimination of this age and financial prejudice that junior sections of all our leading Institutions must fight, and I welcome the formation of any new branches. I would suggest that instead of branches, one Junior Institution should be formed to embrace the whole juniors of the separate institutions.

We have many points to discuss with our senior sections, and to have these points discussed upon a fair understanding, one must show them that juniors are not to be used, as in the past, as means to an end.

I am, Sir, yours faithfully,
London, March 2, 1918. "STUDENT."

NORTH-EASTERN SECTION OF JUNIOR INSTITUTION OF ENGINEERS.

To the Editor of Engineering.

SIR,—The editorial note in your issue of February 22 and the letter from Mr. Stingat in that of March 1 prompts me to write a few words upon the subject therein mentioned.

As a past-chairman and, for the time being, secretary of the Junior Institution of Engineers, I made it my business to solicit a personal interview with the secretary of the leading Senior Institution of Engineers in Newcastle on the morning of February 12, the day of the meeting to which you have referred. This interview was very courteously granted, and the probability of overlapping and of competition naturally came within the matters that were then informally mentioned. I believe I am correctly reporting the outcome of this informal interchange of views, when I record that mutual expressions of goodwill resulted. Certainly, on my part I endeavoured to make it clear that, having received from several of its members resident in Newcastle a suggestion that steps be taken to enable such members to meet under the auspices of the Institution, it was necessary for the council to ascertain whether such a request was sufficiently well supported numerically by members and prospective members. It was to preside at a special meeting to be held for that specific purpose, at the request of the resident members, that my presence in Newcastle was to be explained. I was particularly concerned, both at the interview and subsequent meeting, in discountenancing, as an official of the Junior Institution of Engineers, any actions or remarks of members or non-members that might conceivably be considered to reflect upon existing local engineering societies, and especially to disavow any intention to run counter to any work that had for its object the technical and social welfare of "students" of local associations.

The Junior Institution of Engineers is not a local society. Its membership is world-wide. It embraces all branches of engineering and allied professions. It is not at all comparable with a student section. It is a junior institution, not merely an institution of juniors. Its continued progress since its formation nearly thirty-four years ago is sufficient proof of its being able satisfactorily to fill a need of engineers, young and old, and, not only are the three chief officers individually members of the three chief senior engineering societies, but, at least one-third of its total membership is proud to proclaim connection with leading British technical institutions; while many of its members hold positions of great responsibility throughout the Empire. These facts alone are a striking vindication of the claim that the Junior Institution of Engineers has no competitive aims to either senior, local or student societies.

Permit me to conclude by saying that at a council meeting held on February 28 it was unanimously resolved to sanction two local sections being established—one to be called the North-Eastern Section, with Newcastle as its centre, and the second to be called the North Kent Section, with Gravesend as its centre.

Sir Charles A. Parsons, K.C.B., F.R.S. (past-president, Junior Institution of Engineers), has kindly ratified his acceptance of election as a vice-president of the North-Eastern Section.

Yours faithfully,
W. A. TOOKEY.

39, Victoria-street, Westminster, S.W. 1.
March 6, 1918.

NATIONAL ALLIANCE OF EMPLOYERS AND EMPLOYED.

To the Editor of Engineering.

SIR,—Next to winning the war, thinking people in the commercial and industrial world are mainly turning their thoughts to the vast and very complicated problem of reconstruction. Everyone, of course, realises that when peace comes the commercial and industrial situation will be an absolutely new one demanding new methods and, above all, a new point of view. Although there is in existence a Ministry of Reconstruction and a number of advisory bodies, there is little indication that the Government is making adequate preparations on definite and well-planned lines. One of the most encouraging signs of the times is that a number of very well-known figures in the commercial world and a number of equally well-known trade union leaders have banded themselves together for the purpose of facing the problem and working out the remedies on their own account, and as such a development is of the utmost concern to all branches of British industry perhaps you will allow me briefly to indicate the lines along which it is taking place.

The National Alliance of Employers and Employed was created in the belief that the industrial problems of the future could only be solved by the parties directly concerned, *e.g.*, the employers and the employed. But how can be brought about a general acceptance of that principle and the working co-operation which it implies? This alliance is setting up in all districts Joint Committees of workmen and employers so that a spirit of closer co-operation can be carefully fostered and their relationships settled between themselves *with the minimum of interference by the State.* The country is gradually being covered with a network of these committees which are directing their attention to the questions of a living wage, hours of labour, women's pay, workshop conditions, housing, provision of opportunities for the workers to obtain a technical and practical knowledge of all matters connected with the trades in which they are engaged, maximum output and wages, provision for the security of employment, organisation and agreements, education and technical training.

Demobilisation is essentially a question on which the great partnership of industry must have a deciding voice. The schemes of a number of Government departments whose efforts are not controlled, co-ordinated or directed by a properly constituted central body can lead only to confusion and a multiplication of the difficulties. The demand of this alliance (which will be put forward at a Mansion House meeting on the 13th inst.) is that powers shall be obtained from Parliament to set up a Central Statutory Board with supreme power to regulate and supervise (1) the reinstatement in normal employment of civilian workers now in Government or controlled establishments, (2) the reinstatement in civil employment of the present forces, (3) any general redistribution of labour arising out of the war. We further demand that two-thirds of the members of the Central Board shall be representatives of employers and employed in equal numbers, appointed by employers' associations and trade unions, that the Employment Exchanges shall be placed under the control of Local Boards similarly constituted, and that where trade unions by arrangements with employers' associations are capable of placing their members in employment they shall have all necessary powers conferred upon them.

These are briefly the lines on which the National Alliance of Employers and Employed is working towards the reconstruction of British industry and the making possible of that vast increase in production under good conditions which will be necessary to meet the unprecedented demands on our commercial and industrial resources which the coming of peace will bring.

Yours truly,
A. H. PATERSON
(General Secretary, National Alliance of Employers and Employed).

64, Victoria-street, London, S.W. 1, March 4, 1918.

MODERN DEVELOPMENTS IN GAS WORKS CONSTRUCTION AND PRACTICE.*

By ALWYNE MEADE, Assoc.M.Inst.C.E.

IN the introduction, the methods and apparatus of the present are contrasted with those of the past century; and, from the comparison of prices given, it is shown that coal-gas to-day, in spite of modern improvements, the introduction of scientific control, and the lavish installation of labour-saving machinery, costs approximately as much to manufacture as it did thirty years ago. The expense of modern manufacture is solely attributed to the abnormal rise in the cost of coal and transport, while during the past three years the wages paid to employees have, in common with other industries, undergone considerable augmentation. The fact is mentioned, that some of the larger gas undertakings adopted the course some years ago of purchasing their own fleets of colliers, a policy first instituted by the Commercial Gas Company, of London. The advantage of such a policy is self-evident at the present time when it is borne in mind that the gas-owned vessels are capable of running at half the present rates of chartering.

Reference is made to the modern requirements of the gas consumer, and to the tendency for the property of calorific power to be recognised in lieu of the time-honoured standard of illuminating power. The removal, in 1905, of the restrictions relating to the presence of sulphur compounds in the gas as distributed is referred to, and passing mention is given to modern processes for the purification of gas, such as the high-velocity catalytic nickel treatment.

Financially, gas companies are suffering at present owing to the statutory restrictions which bind them to the distribution of a limited dividend as the price of their commodity is raised. The steps which the gas undertakings are now taking to seek relief from these obligations are alluded to.

Dealing further with financial considerations, the author goes on to say that capital expenditure per 1,000 cub. ft. is usually the crux of a gas undertaking's condition, and in any well-managed concern this item should undergo reduction as years go on, as a result of the taking up of new business and the extension of plant from revenue. Figures cited as illustrative of the three great metropolitan companies show that while in 1906 the capital expenditure per 1,000 cub. ft. was 11*s.* 2*d.* in 1916 it had been reduced to 10*s.* 0½*d.* per 1,000 cub. ft. of gas sold.

The remainder of the paper is largely devoted to a description of the modern methods of construction employed in gas works, and of the latest forms of plant now used. Up-to-date methods of coal handling are dealt with, and the author speaks of the success of the new type of self-dumping grab as compared with the earlier varieties of this device which require special apparatus for release. By employing the self-discharging grab, it is possible to effect a reduction of 30 per cent. in the time taken to discharge a ship of given capacity. The advantages of employing wire ropes in lieu of ordinary hoisting chains for crane work are alluded to.

The telpher of the non-automatic type is spoken of as one of the most suitable arrangements for handling gas-works materials, particularly hot coke, which introduces conditions of the most destructive nature. Gas-works telphers are normally made to operate at a running speed of 400 ft. to 750 ft. per minute, with a hoisting speed of 80 ft. to 100 ft. per minute. The merits of the telpher and conveyor are contrasted, and it is pointed out that the average speed of the telpher is ten times that of the ordinary hot-coke conveyor.

Modern developments in the plant employed in the retort-house are fully dealt with, and the author states that the advances made in the practical application of the theory of heat interchange have resulted in an enormous saving of sensible heat. In illustration of this it is pointed out that whereas twenty years ago 28 lb. of coke was necessary for the carbonisation of 100 lb. of coal, to-day, with the modern continuous vertical retort, only 11¼ lb. are required for dealing with the same quantity of coal. The construction of the most efficient regenerators for effecting this economy is discussed.

One of the most signal changes during the past decade has been the substitution of the mass system of carbonisation in place of the layer system of light charges. This has necessitated an alteration in the design of the stoking machinery employed, one of the latest machines being the discharger-charger, capable of expelling the coke and of introducing the new charge of coal in a single stroke, the time occupied for this operation being about 60 seconds per retort. A description is given of a machine of this kind. The modern tendency is to employ apparatus dependent upon electrical power, the current (usually direct) being generated by a gas engine driven generator at the works.

Full attention is given to present-day attempts to effect carbonisation on ideal lines by the continuous admission of a small quantity of coal to the retort, and the simultaneous extraction of an equal bulk of coke. The continuous vertical retort has been designed for this purpose, but the author holds the opinion that as regards results of carbonisation the horizontal retort is still able to hold its own in many respects. The various types of vertical retorts are described, and their salient features and dimensions are compared in tabulated form.

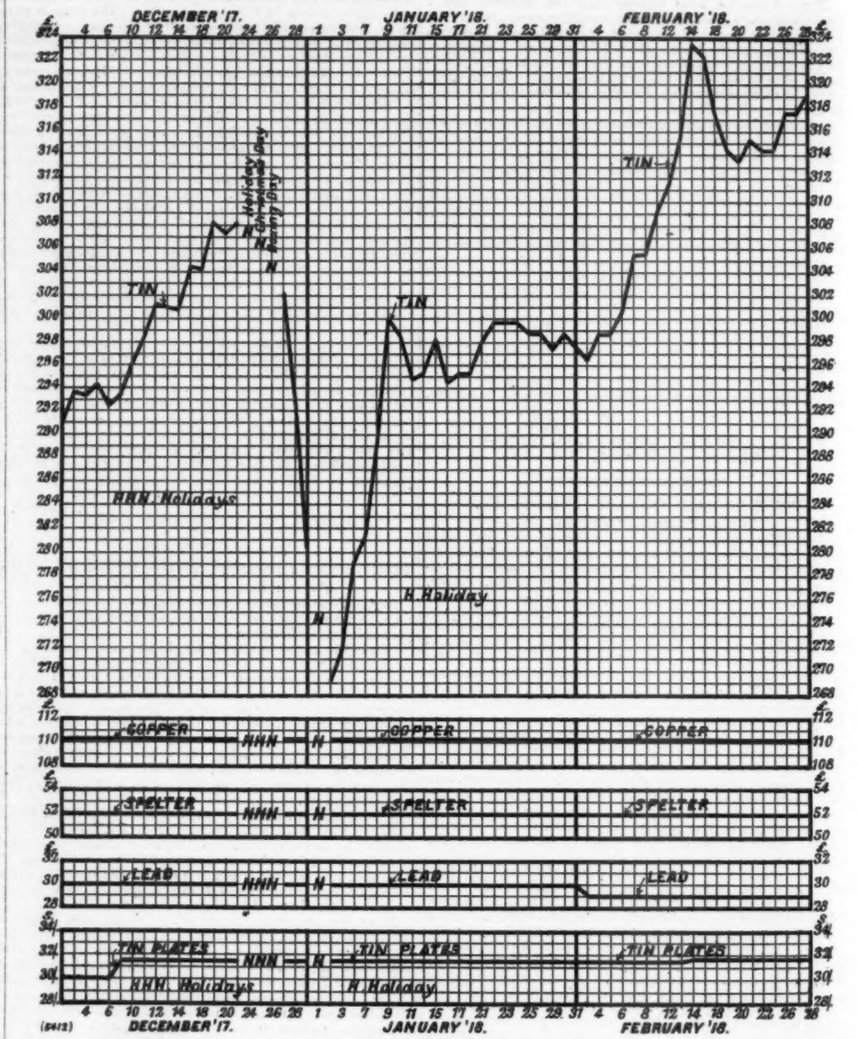
An advantage of the vertical retort, whether of the continuous or intermittent type, is that it affords facilities for steaming the coal charge; thus, within limits, water-gas may be produced simultaneously with the evolution of coal-gas. Recent results indicate that by introducing the principle of "steaming," it is possible to increase the British thermal units produced per ton of coal from 6½ million to nearly 8 million, with a corresponding reduction in the quality of the gas amounting to only some 20 British thermal units per cubic foot.

In conclusion, the author draws attention to the fact that the immense industry which forms the subject of his paper is by no means decadent, but it is, on the contrary, passing through a period of renascence in which it is as yet impossible to see finality. The fact is emphasised that the coal reserves of this country are trifling compared with those of America and the Central Empires, from which it will be appreciated that there is no time to be lost in developing to the utmost advantage the natural gift upon which England's pre-eminence as a nation depends.

* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, March 5, 1918.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagram above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

THE GERMAN ZINC UNION.—We are informed that this Union has agreed to prolong the present agreement till September 30. At present no change will be made in quotations; the demand continues very active, and it is fully anticipated that the use of zinc as a substitute in various industries for copper and other metals, which have become very scarce during the war, will continue when hostilities cease.

GERMAN SHIPPING.—German steamer owners, or rather the shareholders in German steamer companies, are being trained in the acquirement of patience. Some of the largest shipping concerns still avail themselves of the permission granted by the authorities not to issue any reports or publish any balance-sheets. This, for one, applies to the Union Steamer Company, Hamburg, which now, for the fourth time, refrains from publishing any report for the past year.

THE INDUSTRIAL RECONSTRUCTION COUNCIL.—The Industrial Reconstruction Council is holding a meeting at the Town Hall, Manchester, on Wednesday, March 13, at 3 p.m., under the auspices of the Lord Mayor. Mr. G. H. Roberts, Minister of Labour, and Sir William McCormick, Department of Scientific and Industrial Research, will be the leading speakers. This is the first of a series of public towns meetings in all the great industrial centres of the country, arranged by the Industrial Reconstruction Council with the object of awakening national interest in the vital industrial problems of the immediate future. Applications for tickets should be made to the Secretary, the Industrial Reconstruction Council, 8, Bouverie-street, London, E.C. 4.

THE HARDENING AND TEMPERING OF STEEL.*

By Professor C. A. EDWARDS, D.Sc., Metallurgical Department, Manchester University.

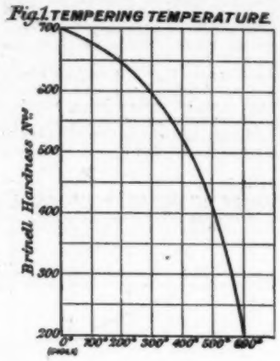
THE very wide variety of steels which are used in the industries of the present day are somewhat arbitrarily classified into two groups. These are the carbon steels and the so-called special steels.

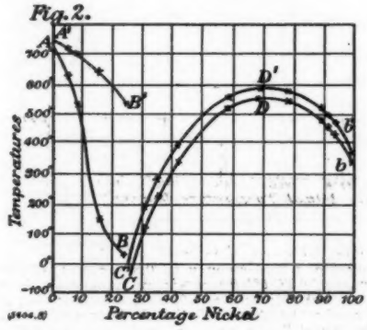
As regards carbon steels, the chief elements other than iron, which are almost invariably present in this class, are carbon, manganese, silicon, sulphur and phosphorus. Phosphorus and sulphur may definitely be regarded as impurities; phosphorus renders the metal "cold-short," whilst sulphur makes it "hot-short" or brittle when at a forging temperature. The presence of small quantities of silicon in carbon steel is often a distinct advantage, especially when considering the casting properties of the metal. With the correct amount of silicon present, the formation of blow holes can be prevented, and the contraction which takes place during solidification can be reduced to a minimum, which means less trouble as regards "piping" and "drawing."

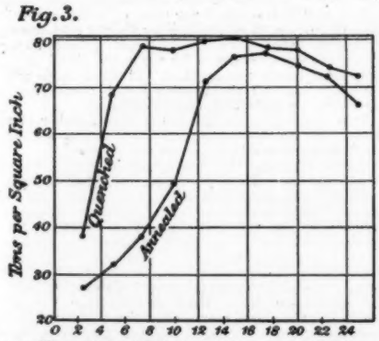
In all carbon steels the presence of a certain amount of manganese is essential. The action of this element is two-fold: (1) It reduces any oxide of iron which may have formed in the steel during the final stages of its manufacture, and since the influence of very small percentages of oxide of iron is so highly deleterious as to make it almost impossible to forge the material, the first action of manganese is that of a cleanser of the liquid metal. (2) An excess of manganese over that required to deoxidise the metal is necessary to combine with the sulphur present, and thus convert that element, from the objectionable compound sulphide of iron into the relatively inert compound sulphide of manganese.

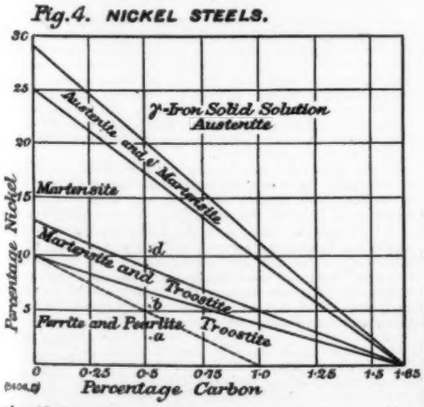
Carbon: This is the most important constituent of all steels. As regards annealed carbon steels, the influence of carbon is more or less progressively to raise the ultimate stress from, say, 18 tons per square inch when no carbon is present, up to something of the order of 40 tons with 0.90 per cent. of carbon. A still greater variation in the properties of these steels can be brought about by subjecting them to different heat treatment. Briefly, heat treatment may be stated to consist (1) of hardening the metal by quenching from a temperature which depends upon the carbon content, and (2) tempering the hardened material by heating to certain low temperatures which are selected in accordance with the particular properties it is desired to obtain. It may here be useful to note, that providing the quenching is properly conducted, the degree of hardness that is attained increases more or less proportionately as the carbon percentage is raised to 0.90.

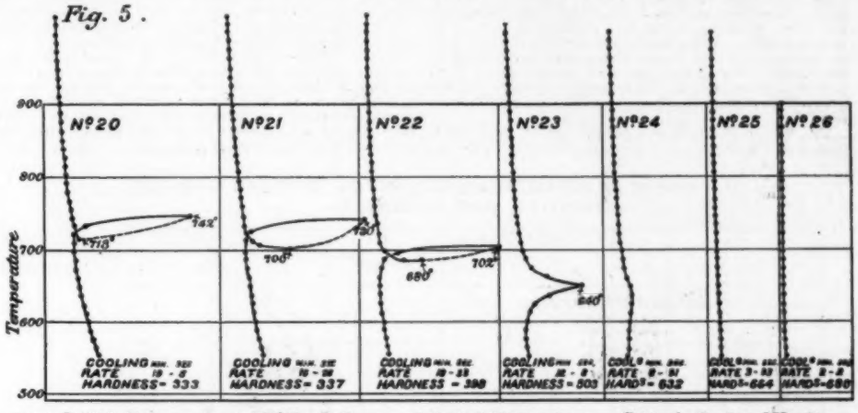
It is quite unnecessary, even if there were time and space at the author's disposal, to attempt to give a detailed description of the facts relating to the cause of the hardening that is produced as a result of this simple











Initial Temperature, 1,200° C. Influence of Initial Temperature on Critical Cooling Velocity.

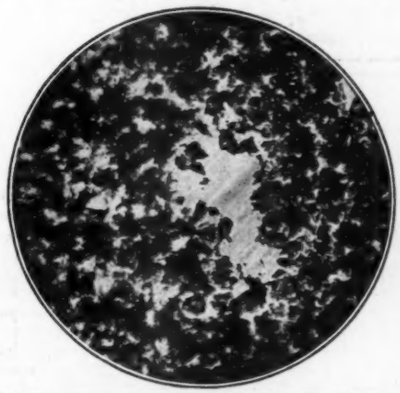


FIG. 6. AFTER CURVE 21; COOLING VELOCITY, 16 MIN. 28 SEC.; HARDNESS, 337.

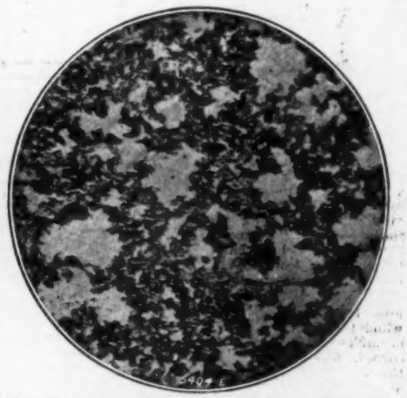


FIG. 7. AFTER CURVE 22; COOLING VELOCITY, 12 MIN. 33 SEC.; HARDNESS, 398.

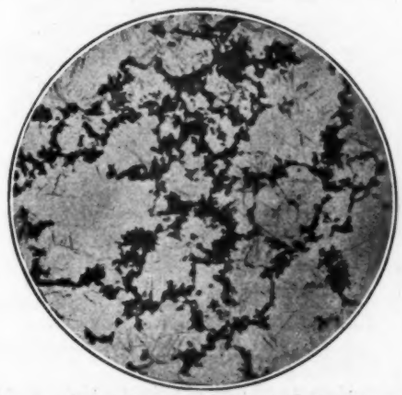


FIG. 8. AFTER CURVE 23; COOLING VELOCITY, 12 MIN. 8 SEC.; HARDNESS, 503.

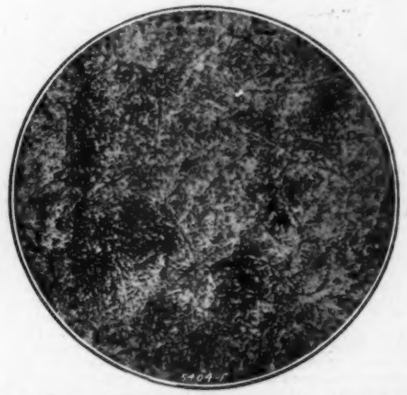


FIG. 9. AFTER CURVE 25; COOLING VELOCITY, 3 MIN. 35 SEC.; HARDNESS, 664.

* Paper read on Saturday, February 9, before the Manchester Association of Engineers.

quenching treatment; and still less is it desirable to give an account of the many conflicting theories which have been advanced to explain why the hardness is thus increased. Nevertheless, it will be advantageous briefly to draw attention to one or two of the more salient features in this connection, because they will make it more easy to appreciate the peculiar properties of special steels.

In the completely annealed or soft state the carbon exists as carbide of iron, Fe_3C, distributed throughout the mass of iron. When this mixture is heated no physical change occurs until a temperature of 700 deg. C. is reached. At that temperature, however, what were previously independent crystals of the compound Fe_3C, and iron, cease to exist, the carbide is dissolved by the iron. This change is accompanied by an evolution of heat.

The action of the above constituent in steel, when heated to 700 deg. C., is in many respects similar to that of the two solids, ice and salt, when they are brought into contact at a temperature above minus 21 deg. C. The only difference being that in the latter instance the solution which is formed is liquid, whilst in the former it is solid. In both cases the original constituents can be separated from solution by cooling when the latent heat of solution is again given out.

Before carbon steel can be hardened by quenching it must be heated to and quenched from a temperature at which the carbide of iron is in solution. If the quenching is sufficiently rapid it prevents the separation of the carbide and the evolution of heat which accompanies that change, and it is the forcible retention of the carbide in this state which causes the hardening. If a carbon steel such as is used for machine-cutting purposes is hardened to its maximum degree, it would possess a very low elastic limit and would consequently be quite brittle.

The well-known operation of tempering is applied to remove this initial brittleness and the internal stresses which are set up in the quenching treatment. The change of hardness that is brought about by tempering carbon steels at different temperatures is qualitatively illustrated in Fig. 1, page 267; the softening is due to the carbide of iron which was kept in solution, by the sudden cooling from high temperatures, being again deposited. Since the amount of carbide in solution can be regulated by controlling the temperature of tempering, it will be seen that any combination of properties between the extremely hard and brittle and the relatively soft annealed states can be obtained. The same results can be produced, though the operation is by no means so readily standardised, by quenching the metal in different mediums or by varying the temperature of the quenching liquids. In both these circumstances the action is to vary the rate of cooling, and this governs the temperature at which the carbide change tends to take place, and also the amount of that transformation which actually occurs.

With carbon steels it is only possible completely to harden the metal if the mass of steel is small. In other words, these remarkable differences in the properties are produced by comparatively slight differences in the rate at which the mass is cooled from the high temperature. For example, the exceedingly hard state is obtained if the time taken in cooling from, say, 900 deg. C. is only a few seconds, but the metal is quite soft if the time taken to cool over the same range of temperature is something of the order of 5 minutes. Hence, it is obviously impossible to bring about any material change of hardness or tensile properties throughout the mass of a large carbon steel forging by modifying the rate of cooling. With special steels, however, this difficulty is completely overcome by the introduction of such elements as nickel, manganese, tungsten, chromium, &c., which may be regarded as producing the same effect as is attained by quenching ordinary carbon steels.

Broadly speaking, the above and other elements lower the normal temperature of the carbide change, and thus influence the general mechanical properties of the mass in a manner similar to that of rapidly-cooling carbon steels. By varying the percentage of these special constituents the temperature of the carbide change can be lowered to any degree down to the atmospheric temperature, and, in consequence of this, steels with almost any desired combination of properties can be readily obtained. There is one great advantage in the use of these special steels, namely, their properties are modified from within, and therefore, practically the same quenching effects are obtained through the whole mass.

In a lecture of this kind it would be impossible to give anything like a complete description of the properties of all the special steels which are in use, but it is hoped that, by taking a few typical examples of some of the more interesting cases, members will be able to form a fairly good idea of the action of the special elements which are used in modern steel metallurgy.

Nickel Steels.—The influence of nickel upon the thermal critical points of iron is shown diagrammatically in Fig. 2. The line A B shows the position of the critical points as they occur when the specimens are slowly cooled from moderately high temperatures. This curve, which also depicts the transformation from the non-magnetic into the magnetic state, indicates that with about 25 per cent. of nickel the change does not take place until the atmospheric temperature is reached. Therefore, with 25 per cent. of nickel and a very small percentage of carbon, the steel is non-magnetic at 0 deg. C. If, however, such a sample is cooled to below 0 deg. C. the magnetic transformation is effected, and these properties are retained even when the temperature is subsequently raised to above 500 deg. C. The corresponding changes with lower percentages of nickel and a rising temperature are illustrated by the line A′ B′.

It follows from what has just been said that steels containing from 0 per cent. to 25 per cent. of nickel when at temperatures within the area A, B B′, may be either non-magnetic or magnetic according to whether they approached those ranges of temperature by being heated or cooled. This group of steels is, therefore, known as the irreversible series, because the magnetic transformation is not a reversible reaction as regards constancy of temperature.

Some idea of the effect of nickel upon the tensile strength of iron will be obtained from a glance at Fig. 3.

In this diagram the lower curve represents the tensile strengths of slowly-cooled specimens, whilst the upper one corresponds with the quenched materials. With the introduction and increase of carbon up to 0.9 per cent. to the nickel-iron alloys the effect is more rapidly to raise the tensile strength, in other words, the carbon acts in the same direction as an increased percentage of nickel. Thus, for example, with no carbon the maximum ultimate stress is obtained with 15 per cent. of nickel, whilst with 0.9 per cent. of carbon practically the same properties are produced with only 7 per cent. of nickel. One interesting result of this has been indicated by Dr. Guillet, as follows:—

From the diagram Fig. 3 it will be observed that a slowly-cooled steel with 7 per cent. of nickel and less than 0.12 per cent. of carbon has a tensile strength of 35 tons to 38 tons per square inch, an elastic limit of 25 tons to 28 tons, and elongation of about 30 per cent. When it is remembered that a steel containing the same amount of nickel along with 0.9 per cent. of carbon, possesses, even after slow cooling, practically the same mechanical properties as a hardened cutting tool, it will be readily recognised that such facts can be advantageously utilised for certain special purposes. Starting with a steel containing 7 per cent. of nickel and 0.10 per cent. of carbon, it is possible by simply carburising the surface and then allowing the article to cool slowly, to obtain the same results as by carburising and quenching an ordinary mild carbon steel. If this is done with the necessary care all the worries which accompany case-hardening by quenching can be avoided.

As a result of investigating a large number of nickel steels, Dr. Guillet has constructed a diagram (Fig. 4) which summarises the data he got.

Whilst this chart is a very useful one, particularly as regards the effect of varying composition upon the internal structure of the steels, there are certain defects which need a more complete explanation than he has given. Perhaps the most important point in this connection is that no account is taken of the influence of initial temperature and rate of cooling. The question of time is an extremely important one and, as I hope to show later, it needs very careful consideration. In fact, it is the author's opinion that metallurgists will in the future have to pay far more attention to the quantitative examination of the time factor than they have generally done hitherto. The necessity of studying the influence of time becomes particularly manifest when we come to consider chromium steels.

Chromium Steels.—Until quite recently different investigators held diametrically opposite views as regards the function of chromium in steel. Some were of the opinion that this element tended to retard the carbide transformation and thus render the steel more or less self-hardening, whilst others maintained that it both raised the temperature of that change and facilitated its completion. Recent work has shown that this diversity of opinion was due to the influence of the time factor not being properly appreciated.

When making experiments with a steel containing a little over 6 per cent. of chromium and 0.63 per cent. of carbon, the author observed the following facts: Specimens, 1 in. cube, were heated to 1,000 deg. C., and then allowed to cool in the following manner—one was taken out of the furnace and allowed to cool on an asbestos pad, in still air, taking about half an hour to reach the ordinary temperature, and the other was more slowly cooled in the furnace, the time taken being about an hour. The former was extremely hard, but the latter was quite soft. The hardness values were:—

	Brinell Hardness No.
Cooled in air	642
Cooled in furnace	281

These facts clearly demonstrate that the rate of cooling plays an important *rôle* in determining whether the steel becomes what is known as self-hardened or not, and they lead to a thorough investigation of the influence of time and temperature upon the hardness of this and other chromium steels.

For this purpose specimens, 1 in. cube, were heated in a small electrical-resistance furnace, and then cooled

Fig.10. EFFECT OF INITIAL TEMPERATURE ON CRITICAL COOLING VELOCITIES AND HARDNESS.

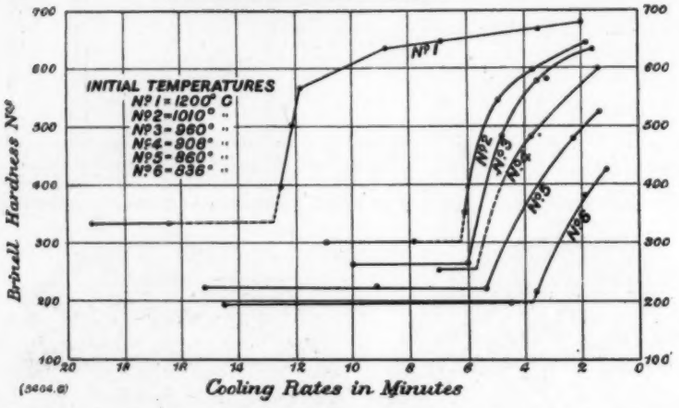


Fig.11. EFFECT OF INITIAL TEMPERATURE ON HARDNESS WITH AIR COOLING.

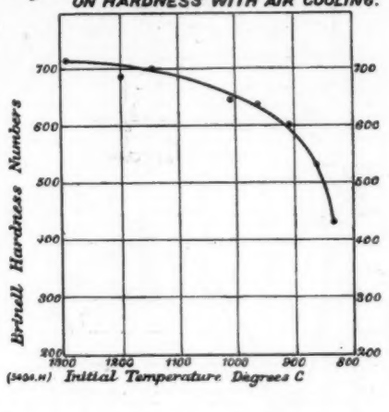


Fig.12. COOLING RATE IN MINUTES.

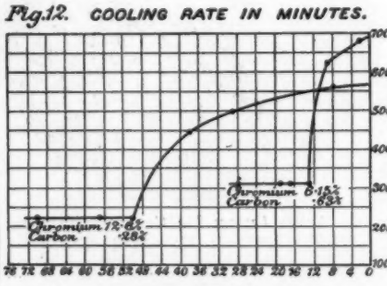
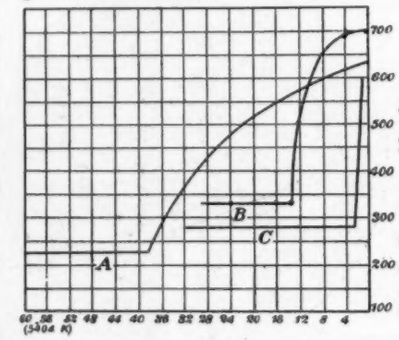


Fig.13. COOLING RATE IN MINUTES.



at varying rates. In order to obtain the necessary variations in the rate of cooling, the samples had to be moved to different positions inside, and in some cases outside the furnace. In all experiments accurate cooling-curve data were taken and hardness determination made.

A typical series of cooling curves are given in Fig. 5, along with the corresponding rates of cooling and hardness values. A few representative microstructure are also given in Figs. 6, 7, 8 and 9. The curves and data in Fig. 5 are particularly instructive, for they give a clear indication of the close connection which exists between the character of the carbide critical point and the hardness of the steel. Comparing the curve No. 20 with No. 21, it will be noticed that the increased cooling rate has lowered the temperature at which the carbide change commenced, but in spite of this, when the transformation once began, the evolution of heat was so great as to cause the temperature of the mass to be raised from 700 deg. up to 730 deg. C. In curve No. 22 the change did not begin until 680 deg. C., and the heat that was then developed was not sufficient to give such a high rise of temperature as in curve No. 21. With curve No. 23, which was only 25 seconds quicker than the previous one, the character of the point is quite different; there is no real rise of temperature, but merely a retardation in the rate of cooling, and it will be observed that this comparatively slight acceleration in the cooling rate has produced a material increase in the hardness of the steel. With still quicker rates, the carbide change can be completely suppressed, and when this is accomplished the maximum hardness is attained. The structures in Figs. 6, 7, 8 and 9 confirm this, the dark areas represent those in which the carbide has fallen out of solution whilst the light areas correspond to an extremely hard constituent wherein the carbon has been retained in solution.

Similar results got with the same steel when cooled from different initial temperatures are plotted in Fig. 10, page 268. Here it will be seen that as the initial temperature is raised the rate of cooling may be decreased to a considerable extent and hardening of the metal is still brought about. In other words, the critical rates of cooling which are represented by breaks in the respective curves become longer as the initial temperature is raised. It should be noted that the rates that are plotted in this diagram are strictly comparable, that is to say, they are times taken to cool the specimens over a given range of temperature which was the same for all experiments. The hardnesses that were obtained for this steel when cooled in the air from varying initial temperatures are plotted in Fig. 11, page 268.

The critical cooling rates at which hardening of the steel becomes evident that have been referred to above are not only influenced by the temperature from which the cooling commences, but also by the carbon and chromium content of the metal. To illustrate this it is only necessary to compare the results that have been got for three other samples, with those that have already been described.

If we first consider a steel containing 12.6 per cent. of chromium and 0.28 per cent. of carbon, after cooling at various speeds from 1,200 deg. C., we find that its hardening characteristics are widely different from those of a steel with 6.0 per cent. chromium and 0.63 per cent. carbon. The hardness-rate data for the two specimens are plotted side by side in Fig. 12. The hardness of the two samples in the annealed state—represented by the horizontal branches of the two curves—are substantially different, and there is a similar difference between the maximum hardness obtained by quick cooling. Perhaps the most interesting feature is that with 6 per cent. of chromium, the cooling rate at which hardening appears is 12.5 minutes, whilst the corresponding rate for the steel containing 12.6 per cent. of chromium is 50 minutes. An even better conception of the effect of composition in this connection will be gained by an examination of the curves in Fig. 13, which relate to steels having the following compositions:—

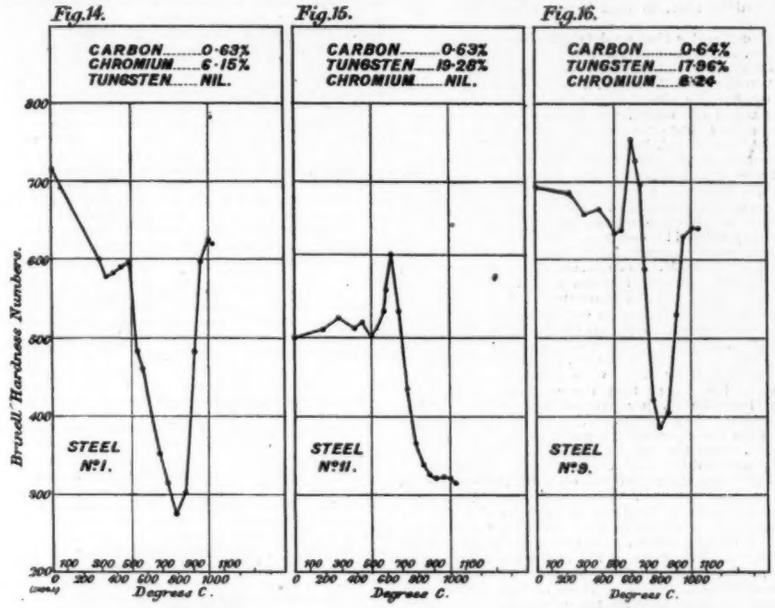
	Chromium.	Carbon.
A	6.18	0.37
B	6.15	0.63
C	6.16	0.97

In this series the chromium is practically the same in each case, whilst the carbon varies from 0.37 per cent. to 0.97 per cent. It will be seen from the respective curves in Fig. 13, that sample A was more readily hardened than B, but that B was more easily hardened than C. This statement is not intended to apply to the degree of hardness which can be attained, but purely to the critical cooling rate. These facts lead us to rather a novel idea from a metallurgical standpoint, for it would appear that by starting with a steel containing 6 per cent. of chromium and 1 per cent. of carbon, if the carbon content could be reduced in any given part of an article to something below 0.60 per cent., it would then only be necessary carefully to adjust the rate of cooling to get those parts with the low percentage of carbon intensely hard whilst the other portions would remain relatively quite soft. In other words, by a process of decarburising any required surface, it should be possible to produce the well-known case-hardening effects which are now produced by carburising other steels.

Some rather crude laboratory experiments have been made in this direction, and the results have shown that case-hardening can be accomplished in this way. Whether this is likely to prove to be of any real practical value or not the author is at present unable to say, but it would be well worth making further experiments with that in view. It might be possible to control the process as easily as the carburising of the nickel steel already cited, and if that is found to be the case, in ordinary times the chromium steel should be considerably cheaper.

Tempering of Chromium Steel.—For discussing the influence of chromium upon the tempering properties, attention will be confined to one example which has been selected on account of its indirect bearing on the question of high-speed cutting tools. Results are plotted in Fig. 14, which illustrate the effect on the hardness of tempering a hardened steel, containing 6 per cent. of chromium and 0.63 per cent. of carbon, at progressively increasing temperatures. These results may be summarised as follows: As the temperature is raised to a little above 300 deg. C., the Brinell hardness falls from above 700 to well below 600. After heating between 300 deg. and 500 deg. C. the hardness becomes a little higher than it was after treating at 300 deg. C. With temperatures above 500 deg. C. there is a rapid fall in the Brinell hardness. It should be noted that the per centages of chromium and carbon in this stee are the same as are usually present in a high-speed cutting tool there is, however, no tungsten present, and without that element such a steel cannot be used for cutting at high speeds.

Tempering of Tungsten Steel.—The effect of heating a hardened steel containing 0.63 per cent. of carbon and 19.28 per cent. of tungsten is shown diagrammatically



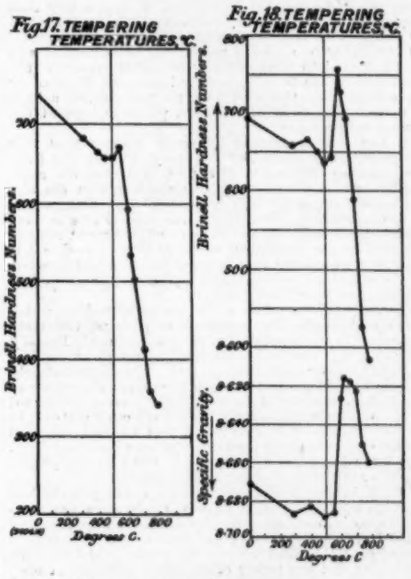


FIG. 19. ANNEALED HIGH-SPEED STEEL.

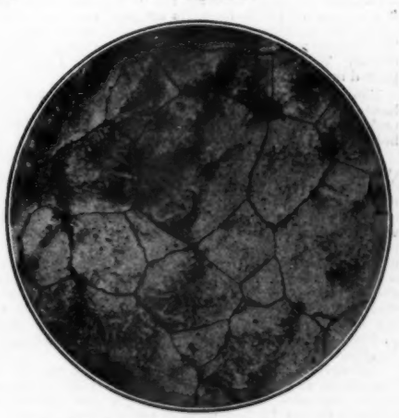


FIG. 20. HARDENED HIGH-SPEED STEEL.

FIG. 21. HIGH-SPEED STEEL HARDENED AT TOO HIGH TEMPERATURE.

in Fig. 15. With the exception of the absence of chromium this material is typical of a high-speed steel. In this instance it will be observed that the Brinell hardness of the steel after hardening in an air blast from about 1,300 deg. C. is only 500, but that this value does not fall after the material has been heated to temperatures up to 500 deg. C. Further, by increasing the secondary heating to a little over 600 deg. C. a marked increase in the hardness takes place, and reaches a value which is greater than it was when first hardened.

Tempering of Chromium Tungsten and High-speed Cutting Steel.—With a steel containing 18 per cent. of tungsten, 6 per cent. of chromium and 0.63 per cent. of carbon, the effect of reheating properly hardened samples is shown in Fig. 16. Here it will be seen that the steel is very hard in the air-hardened state, and that the hardness falls rather markedly as the reheating is raised to 500 deg., but at 600 deg. C. a substantial secondary hardening sets in which makes the material much harder than it was in the initially air-hardened state.

These facts are of considerable importance from the point of view of the machine shop, for they mean that high-speed tools should be treated in such a way that they possess this secondary hardness before they are put into use. This can be effected in one of two ways: (1) The tool may be air-hardened in the usual manner and then reheated to the necessary temperature, or (2) the same results can be obtained by hardening the tool by quenching, from the hardening temperature, in a bath of molten lead or suitable liquid which is kept at the correct temperature.

It has been suggested by some workers that this secondary treatment is not necessary in order to get the best cutting speeds out of a tool, and that the same results can be obtained by using the tool in the air-hardened state and slowly increasing the cutting speed to the maximum. It is quite true that if this is done the frictional heat of the work done will indirectly subject the tool to the secondary heating, but in so doing it must be remembered that the tool becomes unduly worn as a result of its having unnecessarily to pass through a relatively soft condition.

Hardening Temperature.—The temperature from which high-speed steels are hardened is perhaps the most important in the treatment of this class of steel. Broadly speaking, this should be practically as high as possible short of actually melting the metal. This is very clearly demonstrated in Fig. 17, which represents the influence of reheating samples of the same high-speed steel referred to above, that have been air-hardened from 1,050 deg. C. In this instance it will be noted that the steel loses its hardness more quickly than if it had been hardened from, say, 1,250 deg. C., and further, it does not show anything like the same degree of secondary hardening.

The difference in this respect is due entirely to the fact that the tungsten present in these steels does not completely go into solution until temperatures approaching 1,250 deg. C. are attained; and since it is to this element when in solution that we owe the property of secondary hardening and the power of retaining hardness at high temperatures, little or no return is obtained from that costly element unless the tool is heated to a high temperature prior to hardening. It should be stated that care must be taken not to heat the steel to such an extent that a partial melting occurs, for this leads to an embrittling of the tool.

Experiments have been made to determine the variations in the specific gravity of high-speed steel after being air-hardened and tempered at different temperatures. A series of these results are plottted in Fig. 18, along with the hardnesses. A change in the hardness is apparently always accompanied with a corresponding alteration in the volume. Thus with each increase of hardness there is an increase of volume.

Photomicrograph No. 19 is typical of the structure of all chromium-tungsten cutting steels when in the annealed condition; No. 20 represents the normal structure of a properly hardened sample; whilst No. 21 shows what occurs if the steel is overheated, that is, partly melted in the hardening operation. The white irregular-shaped areas or constituent at the crystal boundaries in No. 21 are exceedingly brittle, and impart very inferior cutting properties to a tool.

THE LA LOUTRE DAM, CANADA.—We read in *Power House*, Toronto, that the most important water conservation work thus far undertaken in Canada is that carried out by the Quebec Government and now nearing completion at La Loutre, on the St. Maurice River. It will store up the waters of the St. Maurice for the benefit of its many water powers, and will double the low-water flow. The work is now 80 per cent. completed, and will cost about 1,500,000 dols. When finished, it will create a reservoir of 160,000,000,000 cub. ft., forming the third largest artificial reservoir in the world, being exceeded only by the Assuan reservoir on the Nile and the Gatun Lake on the Panama Canal.

IMPORTED WIRE NAILS ORDER, 1918.—In pursuance of the powers conferred upon them by the Defence of the Realm Regulations, the Army Council hereby order as follows:—(1) It is the intention of the Army Council to take possession of all stocks of wire nails imported or to be imported into the United Kingdom. (2) All persons having in their possession, custody or control any stocks of wire nails of the description aforesaid, are hereby required to furnish such particulars as to their business as may be required by or on behalf of the Director of Army Contracts, verified in such manner as he may direct. (3) Nothing in this Order shall be deemed to apply to any stocks of wire nails of the description aforesaid of less than 5 tons in quantity. (4) This Order be cited as the Imported Wire Nails Order, 1918.

BOILER EXPLOSION AT ST. BURYAN.

A REPORT of a preliminary inquiry by the Board of Trade, under the Boiler Explosions Acts, 1882 and 1890, has recently been issued with regard to a boiler explosion which occurred on September 20, 1917, at Bann's Farm, St. Buryan, R.S.O., Cornwall, the boiler being owned by the St. Buryan Farmers' Threshing Machine Company—a sort of co-operative association, the manager being Mr. William Roberts. By the explosion, the driver was killed, and two other men injured. The boiler was of the locomotive type, 2 ft. 5 in. outside diameter, and 8 ft. 1½ in. in length. It was built of steel, with an internal fire-box, 2 ft. 1½ in. by 2 ft. 1½ in., of Farnley iron. The boiler was equipped with the usual fittings, including two safety valves, and it provided the power for, and was part of, a portable threshing machine, the engine driving the machine being attached to the boiler. The boiler was built by Messrs. Marshall, Sons and Co., of Gainsborough, and was their No. 21,099, having been constructed in 1892, so that it was about twenty-five years old.

The report states that no detailed record of repairs to the boiler, as distinct to the repairs to the machinery, had been kept, but that it was quite clear that in 1905 Mr. Philip Corin, of Penzance, fitted a patch to each side of the combustion chamber, renewed the corresponding stays, retubed the boiler, and fitted a new smoke-box. These patches were to replace patches which had previously been fitted, but when and by whom there was no record to show. Mr. Corin had also renewed the seat of the spring-loaded safety valve. In 1913, Mr. Clemens, a blacksmith of St. Buryan, took off one of these patches and renewed it. When the boiler exploded, there were on the fire-box one patch 13 in. by 10 in. and another patch 11 in. square. No other repairs could be traced, and none appeared to have been carried out.

Mr. Philip Corin, M.I.Mech.E., an engineer of Penzance, and registered teacher of steam and kindred subjects under the Science and Art Department, South Kensington, also holding a first-class certificate of competency as a marine engineer, inspected the boiler at the request of Mr. Mann, the then manager of the company, in 1905, and as a result of his examination, the repairs referred to and carried out by him were effected. He recommended in his report that the working pressure be reduced from 90 lb. per square inch to 80 lb. Mr. Clemens, previously mentioned, made a cursory inspection in 1913 while renewing a patch on the fire-box, but no person, other than the driver, appeared at any time to have inspected the boiler, which was not insured.

The explosion, the report goes on to say, was a violent, disastrous and fatal one. The top of the fire-box gave way along the whole length of the front end plate, the tube plate acting as a hinge, the sides being torn and the top finally coming down and covering the mouth of the smoke tubes. The force of the explosion partly overturned the boiler, blew off the pressure gauge, the fire-door, and whistle, scattering them and the fire-bars in all directions, and moving the whole machine about 8 yards or 10 yards from its original position until it came to rest against a rick of straw that was being built. The driver was killed, and two men injured by flying debris. The pressure gauge, fire-door, and bars were picked up at various distances away.

The explosion was caused by the top of the fire-box having become so thin by wasting as to render it totally unfit to withstand the normal working pressure of the boiler.

In his report to the Board of Trade, Mr. R. Lewis, engineer-surveyor, deals at some length in his general remarks, on the working of the boiler during the last five years, from which it appears that in 1917 the record of work was seven days. The manager of the company, who was assisted by a small committee of about five persons, including the secretary, was responsible for finding work for the machine, while the committee were responsible for a general survey of the work done while the machine was in the vicinity of their homes individually. A certain amount of freedom was allowed the manager in spending on repairs that were urgent, and it does not appear that at any time spending was disallowed.

The driver, named John Priak, had had considerable experience in driving this class of machinery, but was not in any way an engineer, although able to carry out minor repairs; he had worked the machine for nine to ten consecutive seasons and possessed the confidence of the owners in the district as a capable and trustworthy man. His duty was generally to overhaul the engine machinery and boiler, get any necessary repairs and renewals carried out, &c. On September 20, the day of the explosion, work was commenced at 8 a.m. The corn was wet in patches, but apparently there was no difficulty experienced in maintaining the power for driving. Now and again the machine was stopped for the feeders to be cleaned, but seemingly all was going well. Twice during the forenoon the lever safety valve had lifted through excess of steam pressure. At about 1 o'clock the engine was stopped in order to adjust and take the size of the driving belt. At 1.10 p.m. the driver went to turn the flywheel in order to bring the engine into the best position for starting, and immediately the explosion occurred, with the disastrous results above mentioned.

The boiler, according to the statement of the builders, was designed to work at 90 lb. pressure. Mr. Corin, in 1905, advised that it should be reduced to 80 lb. per square inch, but no one connected with the company seemed to know definitely what was the working pressure at this or at any other time.

The surveyor's report goes on to state that the pressure gauge showed a danger (red) mark at 90 lb. per square inch. When he saw the lever safety valve, the indicator showed 100 lb. He tested this balance, and found it practically correct up to 112 lb. The balance was not guarded, protected, or enclosed in any way; so that it could be easily altered at any time by simply turning the thumb-screw. The spring-loaded safety valve which he removed and tested was stuck fast to the seat and did not lift until a pressure of 120 lb. had been applied. After once being released it worked freely at 90 lb. He states that the explosion was caused by the wasting of the fire-box to such an extent as to render it unfit to support the normal working pressure. The plate, originally $\frac{7}{16}$ in. thick, was nowhere up to $\frac{1}{2}$ in., in places less than $\frac{1}{4}$ in., and averaged less than $\frac{7}{16}$ in.

The report further states that Mr. Corin was right in recommending a reduction in pressure to 80 lb., but neither he nor any other person could say whether that recommendation was acted upon. Mr. Mann acted in a businesslike manner in ordering the survey by Mr. Corin in 1905, but since then no thorough inspection had been made, and the manager and committee, since Mr. Mann's time, seemed never to have thought about such a thing; they knew the driver and depended on him. They had a man from the maker's occasionally who carried out repairs to the machinery, but never to the boiler, and thought that when he was there with the driver, those two would see that all was well with the machine as a whole. They gave the driver a free hand to order what he liked and to have such repairs effected as he deemed advisable, but never interfered with his management of the machine or boiler. He did not enter their service until some time after 1905, and he would not know, and no one appeared to have told him, that Mr. Corin had recommended 80 lb. for the working pressure. He would see the pressure gauge marked in red at 90 lb. and it was easy for him to increase the weight on the safety valve if he wished at any time to do so. Some person at some time must have done so, but it was not now possible to ascertain who that person was.

"In conclusion," Mr. Lewis says, "I respectfully suggest that the explosion occurred through wastage of the plate and that this wastage might have been detected had an adequate inspection been conducted any time during the past six or seven years."

Mr. Thomas Carlton, the engineer-surveyor-in-chief to the Board of Trade, makes the following observations in the report to the Assistant Secretary of the Marine Department:—

"This explosion, which unfortunately had fatal results, was the consequence of neglect on the part of those responsible for the working of the boiler to see that it was maintained in a safe condition. Apparently the boiler was entrusted to the care of an attendant who, although he may have had considerable experience in driving engines, was quite unqualified to ascertain whether the boiler was suitable for the steam pressure at which it was worked; and possibly, as in many similar cases, his idea of safety was based on whether the boiler leaked or not. No doubt he did the best he could, and he was not responsible for his limitations or their consequences. It, however, behoves all owners of boilers to see that these boilers and mountings are periodically examined at suitable intervals by one competent to ascertain their condition, and suggest any repairs necessary to secure safety in working, and the owners in the present instance do not seem to have realised their serious responsibilities in this respect."

WOLFRAM DISCOVERY IN QUEENSLAND.—The Minister for Mines in Queensland has received a telegram from the Warden at Port Douglas stating that prospectors have reported the discovery of a highly payable wolfram lode on the eastern slope of the main coastal range south-west of Port Douglas. The deposit is in dense scrub country. The Warden also advises that leases and claims have been applied for to him at Port Douglas and that he is forwarding the Minister a full report of the discovery. So far as the officials of the Mines Department are able to determine, the new find is in the neighbourhood of Mount Carbine, from which large supplies of wolfram are now drawn. It is considered probable the new lode is on a timber reserve near Mount Carbine. The price for wolfram is at present fixed by the Commonwealth, the flat rate being 2*l.* 5*s.* per unit. Hitherto the largest supplies of wolfram have been drawn from Wolfram Camp, on the Hodgkinson, and from Mount Carbine, already mentioned. It is hoped the new find may extend the source of supply of this useful mineral.

SAMPLES OF GERMAN AND AUSTRIAN GOODS.—We read in *The Board of Trade Journal* that an exhibition of samples of goods of enemy manufacture, including many recent additions, is now being held in the new Sample Rooms of the Department of Commercial Intelligence (5th Floor), 73, Basinghall-street, London, E.C. 2. The exhibition is open to British manufacturers and exporters of British goods every week-day between 10 a.m. and 5 p.m.; Saturdays, 10 a.m. to 1 p.m. The samples, which number approximately 10,000, are of considerable variety, and are labelled with prices (where available), and the name of the country in which the goods are sold. Certain of the samples represent quite recent designs from enemy sources, and should be of interest to British manufacturers desirous of obtaining information respecting the new styles of goods at present being manufactured in enemy countries. The markets represented by the samples, are as follow: United Kingdom, British India, Canada, Australia, New Zealand, Africa (South, East and North), Russia, Sweden, Netherlands, Denmark, France, Portugal, Italy, United States of America, Central and South America, Siam, China and other Far Eastern markets.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

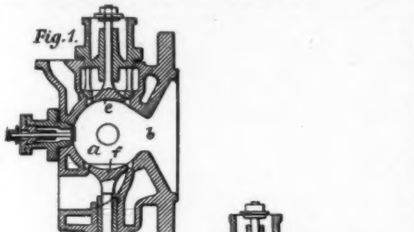
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

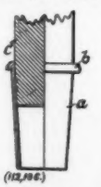
112,096. E. Gardner, Patricroft. Internal-Combustion Engines. (4 *Figs.*) May 26, 1917.—This invention relates to internal-combustion engines of the type in which air only is compressed during the compression stroke, and in which the fuel is injected into a combustion chamber at or just prior to the point of maximum compression, so that combustion takes place in said chamber due to the ignition of the fuel by the high temperature compressed air assisted by the hot surface of the chamber, or if desired by an electric spark. The com-



bustion chamber *a* is made of spherical or approximately spherical form, and has the portion adjacent the engine cylinder and around the restricted exit water-jacketed. Two fuel-injection sprayers *c*, *d*, are disposed at diametrically opposite sides of said chamber, and have their axes in line. The spray issues therefrom in conical form and the particles of fuel are brought to rest by impinging upon one another before they reach the surface of the combustion chamber. The spherical combustion chamber is provided with inlet and exhaust valves. (*Accepted December* 31, 1917.)

MINING, METALLURGY AND METAL-WORKING.

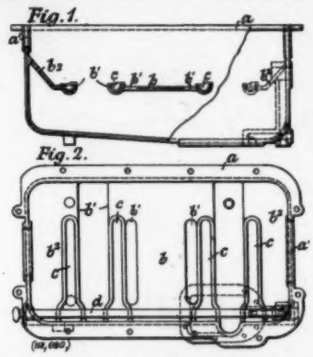
112,106. S. A. Cosgrave, and The Malcast Foundry (1915), Limited, Walsall. Pit Props. (1 *Fig.*) July 31, 1917.—This invention relates to pit props, and provides a prop shoe or extension which permits the prop to yield sufficiently under the pressure of the earth without crushing. A malleable iron shoe *a* or extension is made to a tapered form internally, and also if desired externally. Preferably the upper end of the shoe is reinforced by a collar *b* cast integrally with or shrunk on the shoe. In use one end of the prop *c* is shaped to enter the upper end of the shoe, and then the combined prop and shoe are placed in position in the mine working. By the pressure of



the earth the prop is pushed further into the shoe, and in the event of an increase of load the prop is pushed still further. Or the shoe being hollow, is pushed into the earth. The prop is thus able to yield in the direction of its length sufficiently to accommodate itself to the pressure, and risk of crushing of the prop is thereby reduced or eliminated. Two or more props (virtually forming a single prop) may be inserted in the same shoe. If the extension afforded by one shoe is insufficient, two or more shoes are nested together. For this purpose, both the outsides and insides of the shoes are similarly tapered as shown. The shoe may be applied to either end or both ends of the prop. (*Accepted December* 31, 1917.)

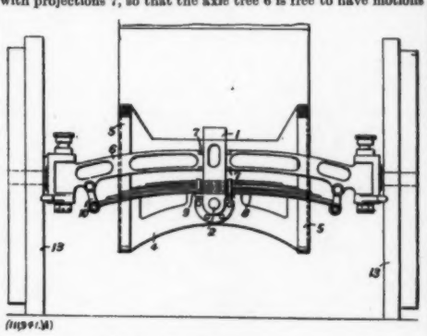
MOTOR ROAD VEHICLES.

112,080. A. J. Dawson, and The Hillmann Motor Car Company, Limited, Pinley, Coventry. Lubricating Engines. (3 *Figs.*) April 4, 1917.—The invention relates to that type of crank-case having a false bottom, lubricating troughs carried by or forming part of the false bottom, and apertures in the false bottom between the troughs to allow any oil escaping from the troughs to pass into the lower part of the crank-case. The crank-case *a* is provided with a false bottom *b*, perforated at *b*1, to allow any surplus oil on top thereof to pass into the bottom of the crank-case *a*. This false bottom *b* has ends *b*2 which slope downwards towards the general level of the bottom *b*. The lubricating troughs *c* are U-shaped in cross-section, and are carried by the false bottom *b*, and each is made higher along the rear edge (as seen in Fig. 1) than along the front edge. The troughs *c* are fed, as usual, by a perforated lubricating pipe *d*, shown only in Fig. 2, through which the oil is pumped, and any



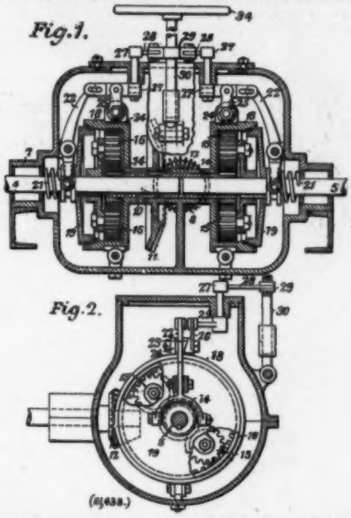
surplus oil passes from the trough *c*, through the apertures *b*1, into the bottom of the crank-case *a*. When the vehicle is ascending or descending a steep hill, the oil in the bottom of the crank-case collects beneath one of the sloping ends *b*2 and is thus prevented from running out of the main bearings. Should oil be splashed up through the apertures *b*1 and run to one end of the crank-case *a*, the sloping end *b*2 will return the oil towards the apertures *b*1 and allow it thus to escape, instead of passing through the main bearing *a*1. (*Accepted December* 31, 1917.)

111,941. G. F. Joseph, Highgate, and W. H. Brown, New Town, Huntingdon. Motor Road Vehicles. (3 *Figs.*) January 22, 1917.—This invention refers to the suspension and springing of motor-driven gun carriages and other vehicles. A loop-like carrier 1 is pivoted so that it can rock laterally upon a pivot-pin 2 located longitudinally of the vehicle and in the vertical central plane thereof; the pivot-pin 2 being supported in bearings in two parallel horn plates 3, 4, which extend transversely of the vehicle, and are fixed to and carried between vertical guides 5, the horn plates and vertical guides being connected to the framework of the vehicle. The loop-like carrier 1 is thus free to rock about the axis of the pivot-pin 2 between the horn plates 3 and 4. The axle tree 6 passes through the loop-like carrier 1, being provided on each side of the carrier 1 with projections 7, so that the axle tree 6 is free to have motions



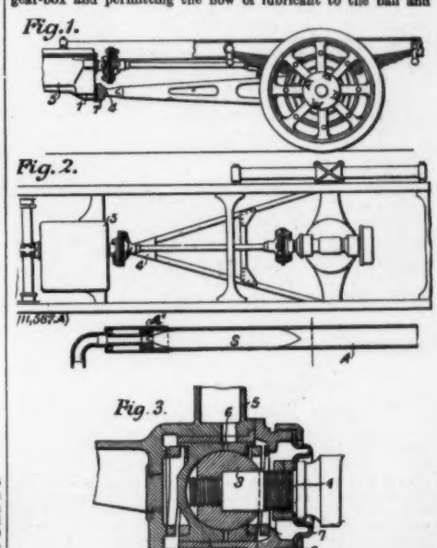
in the direction of the length of the loop-like carrier 1, but is restrained against motion relatively to such loop-like carrier in the direction of the axle tree. A leaf spring 8 also passes through the carrier 1 and is secured to the base thereof by the usual straps 9, and each end of the leaf spring is connected by links 10 to the axle tree 6, so that the motions of the axle tree 6 in the carrier 1 are resiliently restrained by the spring 8. The axle tree 6 passes between the vertical guides 5, as do also the ends of the leaf spring, the guides 5 being in a vertical plane extending transversely of the vehicle, so that the axle tree 6 and the leaf spring 8 can rock about the axis of the carrier 1 and within the guides 5, whereby they are maintained during their vertical movements in a plane transversely of the axis of the vehicle. The axle tree 6 is fitted with stub axles upon which the road wheels 13 are carried. (*Accepted December* 28, 1917.)

111,438. Caterpillar Tractors, Limited, London. (*The Holt Manufacturing Company, Incorporated, Stockton, California, U.S.A.*). **Steering Gear.** (3 *Figs.*) June 11, 1917.—This invention relates to steering gear mechanism for vehicles of the kind in which the vehicle is steered wholly or partly by varying the relative speeds of the driving members on each side of the vehicle. Drive shafts 4, 5 are positioned transversely of the main frame. Surrounding the drive shafts 4, 5 is a sleeve 10, upon which is secured a bevelled gear 11, to which power is transmitted from a driving pinion 12 on the end of the propeller shaft. Keyed on each end of the sleeve 10 are spur-gear pinions 14, each adapted to transmit power to a plurality of intermediate pinions 15 carried by a spider web of which there are two, one being secured on each drive shaft 4, 5. Loosely-mounted on the sleeve 10 are the members 18 of conical friction clutches 18, 19, the complementary members 19 being keyed to and slidably mounted on each shaft 4, 5. The members 19 are normally held in engagement with the members 18 by springs 21, but they are adapted to be brought into or thrown out of engagement with the members 18 by means of levers 22. Surrounding each clutch member 18 is a brake band 24, and each of these bands is adapted to be tightened or released by levers 25, which



co-operate with the levers 22, each of which is operated by means of an independent bell crank 27 and controlling links 28, connected with a cross-arm 29, the latter being secured on a pivotally and turnably-mounted post 30. The double mounting of post 30 permits the post and its socket to be swung either forward or backward or to be turned about its axis by a handwheel 34. The post 30 is provided for the purpose of controlling the transmission of power from the propeller shaft to the driving shafts and forms a single means by which the different operations are effected. (*Sealed.*)

111,587. Halley's Industrial Motors, Limited, and G. H. Halley, Yoker, Glasgow. Motor Vehicles. (3 *Figs.*) February 3, 1917.—This invention relates to a combined torque rod and radius-rod assembly for motor vehicles having the point of thrust at the gear-box. According to the invention, the housing for the socket member, which serves to receive the ball-member of the rod and which forms a component part of, or attachment to, the gear-box of the vehicle, is formed with a lubricant passage in communication with the interior of the gear-box and permitting the flow of lubricant to the ball and

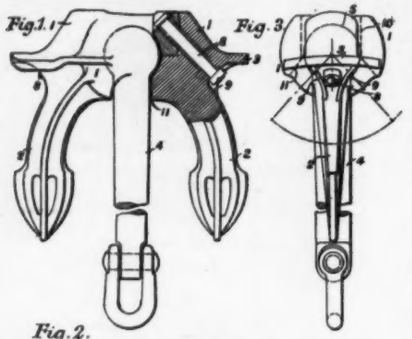


socket joint from the gear-box, whereby the necessity for an independent lubricator or the like is avoided. 1 denotes a housing for the socket member 2, which serves to receive the ball member 3 of the rod 4. As shown, the housing 1 constitutes a component part of the gear-box 5, and is formed with a lubricant passage 6 in communication with the interior of the gear-box 5. The rod 4 is enveloped near its junction with the ball member 3 by a U-leather annulus 7 or the like, the outer edge of which is clamped by the end cover 8 of the housing 1, and the inner edge of which is clamped to the rod 4. (*Accepted December* 12 1917.)

SHIPS AND NAUTICAL APPLIANCES.

111,960. N. Hingley and Sons, Limited, and J. E. Fletcher, Dudley. Anchors. (3 *Figs.*) March 14, 1917.—This invention has reference to anchors of the stockless type, in which the head and flukes are in one piece, and they and the anchor shank lie in the same plane when these two relatively

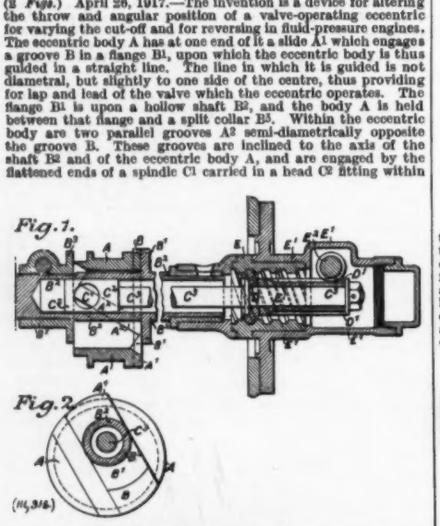
movable parts are in the mid-position, and the head and flukes are adapted to oscillate about a joint between the outer end of the shank and the head. The body of the anchor comprises the head 1 and flukes 2, and tripping parts 3, and the shank 4 has a spherical head 5, which fits and works in a socket 6 formed in the bottom of the recess 10, formed in the outer end of the head as usual, and this shank head is held in its socket 6 by removable holding blocks 7 fitted in recesses at the ends of the recess 10, they being of smaller width than the centre portion of the recess itself, which, as seen in Fig. 2, is of just sufficient size to receive the head 5; and the inner surfaces of the blocks are of spherical contour to correspond with the spherical head 5,



and are secured in position by bolts 8 which pass diagonally down through the head, and the fastening nuts of which lie in the recess formed by the underside of the trippers 3, the outside surface of the flukes 2, and the webs 9, which protect them. The upper surfaces of the blocks are inclined towards and lead on to the surface of the head 5, so that the interior of the recess or chamber 10 will always be washed through with water and be self-cleansing. The aperture 11 on the inner side of the head 1 is in width sufficient to freely take the shank 4 as seen in Fig. 1; and is extended on each of the central positions for a certain distance to allow the body of the anchor to move about the axis of the head 5 angularly in relation to the general plane of the anchor. (*Accepted December* 28, 1917.)

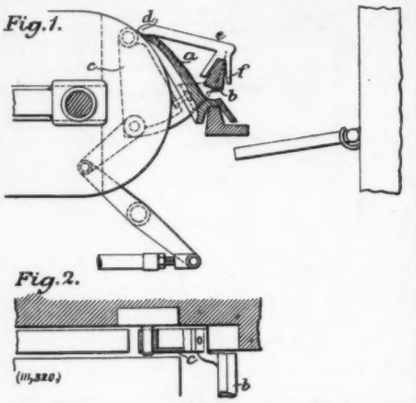
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

111,316. S. E. Alley, Polmadie, Glasgow. Valve Gear. (2 *Figs.*) April 26, 1917.—The invention is a device for altering the throw and angular position of a valve-operating eccentric for varying the cut-off and for reversing in fluid-pressure engines. The eccentric body A has at one end of it a slide A^1 which engages a groove B in a flange B^1, upon which the eccentric body is thus guided in a straight line. The line in which it is guided is not diametral, but slightly to one side of the centre, thus providing for lap and lead of the valve which the eccentric operates. The flange B^1 is upon a hollow shaft B^2, and the body A is held between that flange and a split collar B^3. Within the eccentric body are two parallel grooves A^2 semi-diametrically opposite the groove B. These grooves are inclined to the axis of the shaft B^2 and of the eccentric body A, and are engaged by the flattened ends of a spindle C^1 carried in a head C^2 fitting within



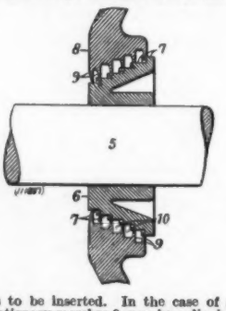
the shaft B^2 and formed on a spindle C^3. Endwise movement of the spindle C^3 causes the flattened ends of the spindle C^1, by engagement with the grooves A^2, to traverse the body A across the axis of the shaft B^2, and thus vary its throw and its relative angular position. The spindle C^3 is carried in such a manner that it cannot move endwise in a sleeve free to rotate upon it and bearing a screwed part D and a part having spur teeth D^1. The screwed part D engages within a nut E held stationary in a casing E^1, while the toothed part D^1 is engaged by a rack bar E^2 carried in the casing E^1 and provided with any convenient means for its endwise movement—which, as it will be seen, causes the sleeve to be rotated, and by engagement of its screwed part D with the nut E to move endwise, the spindle C^3 thus adjusting the angular position and throw of the body A. (*Accepted December* 5, 1917.)

111,320. London Electric Supply Corporation, Limited, London, and A. G. Fox, New Cross, London. Furnaces. (5 *Figs.*) November 17, 1916.—This invention relates to furnaces provided with travelling or chain grates for feeding the fuel. *a* is a pivoted lean-to plate closure or seal between the grate and the ash-pit, and *b* is an adjustable bar which extends across the width of the furnace at the rear of the grate. The bar may be secured to levers *c* at opposite ends, said levers being situated either inside as shown, or outside of the furnace. The levers are provided with pivot bearings so that when turned the bar moves in the arc of a circle. Pivotally mounted on the bar is a stripper or fuel controller *e*, which preferably consists of a number of independent sections, each of which is provided with a toe-shaped projection *d* which engages with the rear end of the grate by gravity. The pivotal mounting of the stripper is preferably such that while allowing of a certain movement towards and away from the grate it prevents the stripper from being thrown over its centre of gravity so that it would remain out of contact with the grate. This may be accomplished by providing the stripper *e* with a slotted or forked base *f*, which rests on the adjustable bar *b*, the sides of the slot being divergent so that



considerable movement of the stripper may take place before the inner sides of the slot come into contact with the side of the bar, but not sufficient movement to allow the centre of gravity being moved to the side of the plane of their pivoting points remote from the grate. The toe *d* of the stripper bar is arranged approximately in line with the axes of the lever points, so that when the levers are moved the toe remains practically stationary and the working face of the stripper moves between positions substantially tangential to the rear end of the grate and substantially radial thereto. (*Sealed.*)

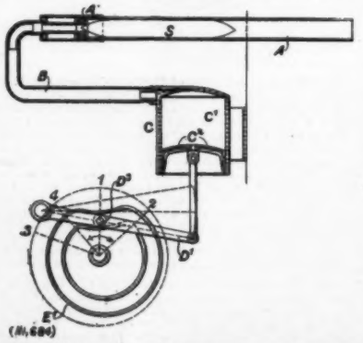
111,897. The British Thomson-Houston Company, Limited, London (*General Electric Company, Schenectady, U.S.A.*). **Shaft-Packing Devices.** (2 *Figs.*) December 12, 1916.—The invention relates to shaft packings for rotary shafts, 5 indicates a rotatable shaft. Mounted on the shaft is the rotating member 6 of the packing. It is frusto-conical in shape, and has on its outer face a series of flat annular surfaces 7, thus forming a series of steps. 8 indicates a stationary member through which the shaft passes and between which and the shaft



the packing is to be inserted. In the case of an elastic fluid turbine, the stationary member 8 may be a diaphragm or turbine casing. In any event, it is formed with a cone-shaped opening formed by a series of projecting packing rings 9 between which are annular spaces 10. The packing rings 9 are shown as being formed integral with the stationary member. As is clear from the drawing, they are stepped so as to co-operate with the surfaces 7, and it is between these surfaces and the rings that the packing effect is produced. (*Accepted December* 28, 1917.)

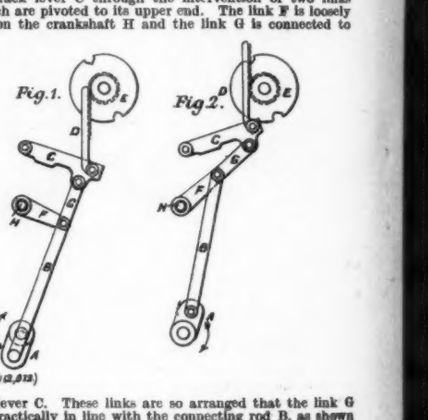
TEXTILE MACHINERY.

111,684. The Pneumatic Loom Syndicate, Limited, Birmingham, and M. T. Pickstone, Prestwich, Manchester. Pneumatic Picking Motions. (1 *Fig.*) October 4, 1916.—This invention relates to that type of loom in which the propulsion of the shuttle is effected pneumatically. The object of the



present invention is to provide improved means for controlling the movements of the shuttle whereby the latter, prior to being picked, is checked by a cushion of air on entering the shuttle-box, is then drawn to the inner end of the box and retained there by suction, and is subsequently propelled from the box by a sudden increase of pressure produced behind it. A is a shuttle-box, which is in the form of a tube open at one end and provided at the other with a tubular connection B leading to the cylinder C^1 of a pump C. A piston C^2 within the cylinder C^1 is connected to a lever D^1 provided with a bowl D^2 that runs in a groove of a cam E^1. When the parts are in the positions shown, the shuttle S is up against a buffer A^1, the piston C^2 is moving over its bottom centre, and the reed is just beating up the fell of the cloth. As the cam E^1 rotates in the direction indicated by the arrow, the lever D^1 is rocked about its pivot. When the cam has rotated through 45 deg. from the position shown, the bowl lies in the cam groove in the position indicated by the radial line 2: during this movement the shuttle has been propelled from the box: the piston has been moved up to the top of its stroke, moving over the top centre: and the reed has been caused to approach the bottom or rearward end of its stroke. Further movement of the camshaft through approximately 245 deg. brings the bowl to position 3; the piston C^2 has during this movement come downward to the middle of its stroke, where it comes to rest. During approximately the next 30 deg. of movement of the camshaft, that is to say, while the bowl is brought from position 3 to position 4, there is no movement of the piston; during this period of dwell the shuttle S (having been, in the meantime, propelled from the other side of the loom) re-enters the tube A and, meeting a stationary cushion of air, gradually comes to rest in a positon within the tube A that depends to a great extent upon the quantity of the weft in the shuttle; the reed meanwhile is moving toward the fell of the cloth. Continued movement of the camshaft brings the bowl to position 1. During the movement from position 4 to 1 the piston has been brought rapidly to the bottom of its stroke, thus producing a reduction of pressure at the inner end of the tube A, with the result that the shuttle is sucked home against the buffer A^1 and is held against rebound until the continued movement of the camshaft brings the parts again to the first position as indicated by full lines. (*Accepted December* 19, 1917.)

112,072. Butterworth and Dickinson, Limited, and A. Prior, Burnley. Drop-Box Looms. (2 *Figs.*) March 16, 1917.—This invention relates to drop-box looms working on the Eccles principle, and consists in providing improved means for producing a dwell in the box-motion which will cause each box to remain practically stationary and in line with the shuttle race at each change and thereby avoid any possibility of the shuttle becoming damaged as it enters or leaves the box. A indicates the usual crank, B the connecting rod, C the rack lever, D the rack bar, and E the disc. The connecting rod B is connected with the rack lever C through the intervention of two links F, G, which are pivoted to its upper end. The link F is loosely mounted on the crankshaft H and the link G is connected to



the rack lever C. These links are so arranged that the link G remains practically in line with the connecting rod B, as shown in Fig. 1, during the greater portion of the crank-pin's travel, but is moved out of line therewith and more or less into line with the other link F, as shown in Fig. 2, as the crank-pin approaches the upper end of its travel with the result that the two links F, G, work with a toggle action during the upper portion of the crank-pin's throw, and practically no motion is imparted to the rack lever C until the link G that is attached thereto is again brought into line with the connecting rod B, whereupon the rack lever is again actuated for moving the rack bar. This dwell is sufficient to cause each box to remain practically stationary in line with the shuttle race for a period at each change. (*Accepted December* 31, 1917.)

UNIVERSITY COLLEGE, LONDON.—The annual report of University College, London, has just been issued. It shows that, whereas in normal times the total number of students, day and evening, amounts to about 2,200, the number last session was 1,240. This number included 121 members of H.M. naval and military forces, for whom special courses were provided, and 150 students who attended special vacation courses, so that the actual number of ordinary students was 960, of whom 547 were women. The report further shows that, whereas the normal fee revenue amounts to about 30,000*l.* a year, the fee revenue last year was only 14,000*l.* Economies of every kind have been introduced, and all expenditure that can be deferred has been so deferred. The financial position, however, is, naturally, a difficult one. It is anticipated that, unless further help from the treasury is forthcoming, there will be a deficit at the end of the current session of nearly 9,000*l.* on the college establishment account. While the ordinary activities of the college have been maintained to meet the needs of the students actually in attendance, all available energies have been directed towards war purposes, of which some account is given, but obviously details must be held over until the end of the war. Among the important developments of the year may be noted the admission of women to the Faculty of Medical Science; the reorganisation of the Department of Italian, providing for a professorship, a readership and an assistant; the institution of a Department of Scandinavian Studies; and a movement for the institution of a Department of Dutch Studies. The *Pro Patria* list includes about 2,500 names of past and present members of the college who are taking an active part in one or other of the services connected with the war. Of these no less than 195 have already fallen.